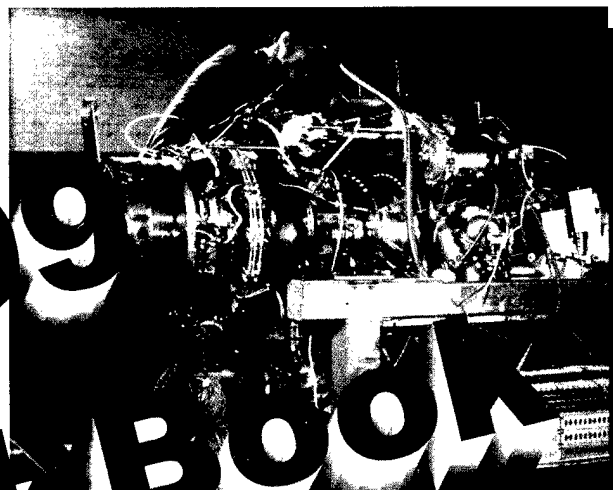
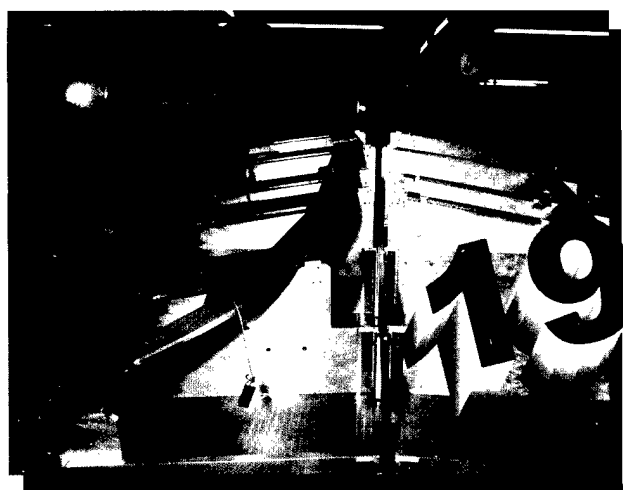




# AIR FORCE RESEARCH LABORATORY

## MANUFACTURING TECHNOLOGY



# 1999 Project Book Update



A Supplement to the 1998 ManTech Project Book

DISTRIBUTION STATEMENT A

Approved for public release;

## **APPROVED FOR PUBLIC RELEASE**

The Manufacturing Technology (ManTech) Project Book is designed to provide information on significant accomplishments and to expedite direct exchanges between government and industry management concerned with broadbased ManTech activities. Recipients are encouraged to route the publication to associates and other organizational functions engaged in manufacturing related program activities. All comments relating to this supplement should be directed to AFRL/MLOP, Bldg 653, 2977 P Street, Suite 13, Wright Patterson AFB, OH 45433-7739. Telephone: (937) 255-4623. Approved for public release (ASC/PA#98-1926).

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# Introduction

This document is a supplement to the Air Force Research Laboratory Manufacturing Technology "1998 Project Book." It is not a replacement, but rather an enhancement to an already vital "living" report with the specific purpose of promoting the transfer of technology. It is organized in such a way as to provide information needed to decide whether the technology described will be useful. For further questions or information, the Technology Information Center's telephone number is listed below.

In this supplement, **new projects** since the publication of the 1998 Project Book in November 1997 are summarized on a single page. The summary contains an explanation of the need for the project, the approach taken to accomplish the effort, the benefits expected to be realized, the current status, the name of the project engineer, and the performing contractor. For **projects completed** since the printing of the 1998 Project Book, there is a summary of the final benefits of the program, the status of the final technical report or the report number, and the Project Book page number for reference purposes. For active projects (those described in the 1998 Project Book which are still active), there is information on the current status of the project and the Project Book page number.

For current information on a variety of division activities, visit the **Manufacturing Technology Division's homepage** at: <http://www.afrl.af.mil>

In all cases, for additional information, submit a request specifying which programs are of interest and what information is needed to:

**Technology Information Center**  
**AFRL/MLOP, Bldg 653**  
**2977 P. St., Suite 13**  
**Wright-Patterson AFB, OH 45433-7739**  
**(937) 256-0194**  
**fax: (937) 256-1422**

# Completed Projects

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## Advanced Modular Factory

(Page 2) Cooperative Agreement Number: F33615-96-2-5113 ALOG Number: 1488

Technical Report Number: In Progress

This program focuses on extremely broad implementation of lean production principles across the entire Raytheon missile production complex. Originally based on a model implemented by John Deere, Raytheon developed a factory-wide vision and invested heavily in factory operations, team training, and advanced supplier relations to bring their vision to fruition. Tremendous reductions in cycle time and inventory across the missile portfolio were achieved, including 25 percent reduction in order fulfillment time for the AMRAAM missile and a two-fold increase in inventory turns across the factory.

### Status

*Complete*

*Start date: September 1996*

*End date: November 1998*

### Resources

*Project Engineer:*

*Brench Boden*

*AFRL/MLMS*

*(937) 255-5674*

*Air Force Funded*

*Contractor:*

*Raytheon Missile*

*Systems Company*

## C-17 Lean Aircraft Initiative

(Page 4) Contract Number: F33657-95-D-2026 ALOG Number: 1506

Technical Report Number: In Progress

This project sought to demonstrate the benefits of lean production in order to incentivize change, and to reduce the cost of the C-17 aircraft. Specifically, cost reduction and quality improvements were sought for C-17 components through adaptation and implementation of lean principles at the shop floor level. By sharing lean production methods and results through the LAI consortium, change may be incentivized at other aerospace companies, as well as at Boeing facilities.

### Status

*Complete*

*Start date: October 1995*

*End date: October 1998*

### Resources

*Project Engineer:*

*Brench Boden*

*AFRL/MLMS*

*(937) 255-5674*

*Air Force Funded*

*Contractor:*

*Boeing Company*

## Design Information Retrieval Using Geometric Content

(Page 5) Contract Number: F33615-96-C-5615 ALOG Number: 1478

Technical Report Number: AFRL-ML-WP-TR-1998-4053

The need for a software tool to query a large, potentially distributed database of design information is crucial for many different applications like collaborative design environments, parts/supplier selection, design for reuse, product database management and so on. Most of the efforts in this area allow for database search using textual attributes. This project developed an Internet-aware geometric information analysis and retrieval technology that allows a user to search for CAD models with similar geometric content.

### Status

*Complete*

*Start date: April 1996*

*End date: April 1998*

### Resources

*Project Engineer:*

*Theodore Finnessy*

*AFRL/MLOP*

*(937) 255-4623*

*DARPA Funded*

*Contractor:*

*Virage Incorporated*

## Military Products from Commercial Lines

(Page 12) Contract Number: F33615-93-C-4335 ALOG Number: 1254

### Technical Report Number: In Progress

This pilot addresses the issues of dual-use and affordability by producing military components on a commercial line at lower cost and comparable quality to those produced on a dedicated military line. Digital electronic modules compatible with the F-22 Advanced Tactical Fighter and the RAH-66 Comanche Helicopter were processed on a commercial automotive manufacturing line. The data collected throughout the program will be used by the F-22 SPO and the RAH-66 PMO to determine if cost savings are sufficient to warrant future purchases of commercially manufactured military electronic modules. The objective of this project was to apply Lean principles to demonstrate the commercial manufacture of military electronics modules, and measure and transfer results.

#### Status

*Complete*

*Start date: May 1994*

*End date: October 1998*

#### Resources

*Project Engineer:*

*Mary Kinsella*

*AFRL/MLME*

*(937) 255-2461*

*Air Force Funded*

*Contractor:*

*TRW*

## Modular Factory for Electronic Warfare Component Manufacturing

(Page 14) Cooperative Agreement Number: F33615-95-2-5564 ALOG Number: 1264

### Technical Report Number: In Progress

Benchmarking data from the Lean Aircraft Initiative suggests that a modular organization of the factory is a powerful means of optimizing flow. This lean implementation effort focused on demonstration of the modular factory concept against electronic warfare component manufacture, demonstrating emphasis on up-front assessment of cost drivers and affordability concerns.

#### Status

*Complete*

*Start date: October 1995*

*End date: October 1998*

#### Resources

*Project Engineer:*

*Brench Boden*

*AFRL/MLMS*

*(937) 255-5674*

*Air Force Funded*

*Contractor:*

*Northrop Grumman*

## National Excellence in Materials Joining Education & Training

(Page 16) Grant Number: F33615-94-1-4416 ALOG Number: 1224

### Technical Report Number: In Progress

The objective of this effort was to establish a regionally based program entitled which would serve as a model to retrain the manufacturing workforce using a systematically designed and coordinated instruction base. It provided a nationally approved means for attaining industry-recognized diplomas, certificates, and degrees.

#### Status

*Complete*

*Start date: March 1994*

*End date: September 1998*

#### Resources

*Project Engineer:*

*Theodore Finnessy*

*AFRL/MLOP*

*(937) 255-4623*

*DARPA Funded*

*Contractor:*

*Ohio State University*

## Active Projects

### Agile Infrastructure for Manufacturing Systems Pilot

(Page 3) Cooperative Agreement Number: F33615-95-2-5520 ALOG Number: 1349

**Update** - This program demonstrated and evaluated the advanced design, manufacturing, and business transaction processes that enable agility within an organization. The program focused on the technical and cultural tools necessary to bring agile manufacturing to the aerospace industry. The program provided: a working virtual corporation prototype; a proven, scalable support architecture; a template for agile business transactions over the Internet; procedures and metrics for certifying and categorizing agile suppliers; validated metrics for managing an agile virtual corporation; and a migration business plan for the resulting products.

#### Status

*Active*

*Start date: January 1995*

*End date: December 1998*

#### Resources

*Project Engineer:*

*Daniel Lewallen*

*AFRL/MLMS*

*(937) 255-4623*

*DARPA Funded*

*Contractor:*

*Lockheed Martin Corporation*

### Labor Infrastructure for Agile High Performance Transformations

(Page 6) Contract Number: F33615-95-C-5512 ALOG Number: 1366

**Update** - This project developed a case study methodology involving three teams. Case studies were conducted of networks, model for growing networks and maintaining mature networks, complementary network material to go with the NIE material, metrics for network effectiveness, replication model development, and creation and refinement of network. Case studies and histories were prepared on two best practice companies and three target companies, establishment of metrics, customization of handbooks, AHP skills training, collection of metrics, and assess, review, revise transformation plan.

#### Status

*Active*

*Start date: February 1995*

*End date: November 1999*

#### Resources

*Project Engineer:*

*Capt. Paul Bentley*

*AFRL/MLMS*

*(937) 255-7371*

*DARPA Funded*

*Contractor:*

*Work & Technology Institute*

### Lead Time Reduction

(Page 7) Cooperative Agreement Number: F33615-96-2-5620 ALOG Number: 1505

**Update** - This Lean Implementation effort focuses on reducing the critical path for manufacture of the F-22 during full rate production. Specifically, long lead suppliers are identified and a supplier improvement process is piloted at each supplier to resolve production difficulties and reduce cost for both Lockheed and the supplier. This demonstration of lean supplier development and management has potential to reduce the F-22 total production span time by as much as 25 percent.

#### Status

*Active*

*Start date: June 1996*

*End date: June 1999*

#### Resources

*Project Engineer:*

*Brench Boden*

*AFRL/MLMS*

*(937) 255-5674*

*Air Force Funded*

*Contractor:*

*Lockheed Martin Corporation*

## Lean Aerospace Initiative

(Page 8) Cooperative Agreement Number: F33615-93-2-4316 ALOG Number: 1137

**Update** - Lean concepts present the US military aerospace industry with an opportunity to address the challenges presented by both reductions in DoD procurements and world wide-competition. The objective of the Lean Aerospace Initiative is to develop a framework for implementation of a fundamentally different, provable better way of manufacturing, enterprise-wide, that would better support the defense aerospace needs over the next 30 years. Phase I of the LAI concluded in September 1996. It established an Executive Board comprised of senior industry, organized labor, and government personnel to assist in steering the effort (i.e., Air Force lead - ASC/CC). Three Lean Forums were conducted in Phase I to transition research findings to the customer base and establish requirements for both technology and acquisition investment planning processes. Based upon MIT LAI research findings, seven advanced manufacturing demonstration projects which pilot the feasibility of lean practices were funded. Industry members are taking LAI findings and applying lean practices within their companies, as evidenced during government/industry information exchanges. LAI Phase II modified the current cooperative agreement by extending the period of performance three years and expanding the scope of government and industry participation. LAI is accelerating and focusing the pace of change toward lean in the aerospace industry by providing industry leadership with common understanding of principles, priorities and data. LAI provides a collaborative environment to define areas of enabling research and development, benchmark, and share experiences and knowledge.

### Status

*Active*

*Start date: September 1993*

*End date: September 1999*

### Resources

*Project Engineer:*

*Al Taylor*

*AFRL/MLMA*

*(937) 255-3701, ext 233*

*Air Force Funded*

*Contractor:*

*Massachusetts Institute of Technology*

## Lean Sustainment Initiative

(Page 10) Contract Number: F33615-96-D-5608 ALOG Number: 1284

**Update** - This project will make available to the Lean Logistics (LL) community the unique research experience and capability of the Massachusetts Institute of Technology (MIT) in the area of lean principles, practices, and change strategies. This program is expected to stimulate fundamental change within the entire sustainment enterprise and will emphasize the Air Logistics Centers supplier base. The Lean Sustainment Initiative will distill and disseminate existing MIT lean principles and change management knowledge to Air Force LL personnel. Research of world class lean repair commercial organizations will be conducted and critical lean principle and change management lessons learned will be communicated to LL architects. World class commercial repair processes will be compared to determine what to change and how to best accomplish this. This program will help identify "best practices" that should be considered for adoption within the Organic and Private Industrial Base, enabling it to eliminate waste and achieve a lean enterprise posture. In addition, it will help establish integrated workload sector enterprises within the organic industrial base from a product/process perspective.

### Status

*Active*

*Start date: April 1997*

*End date: December 1999*

### Resources

*Project Engineer:*

*Dan Brewer*

*AFRL/MLMP*

*(937) 255-7278*

*Air Force Funded*

*Contractor:*

*Anteon Corporation,  
General Research  
Corporation, International*

## Active Projects

### Military Products Using Best Commercial/Military Practices

(Page 13) Contract Number: F33615-93-C-4334 ALOG Number: 1255

**Update** - This pilot sought to demonstrate the ability to build a more affordable, lighter weight C-17 horizontal stabilizer in an integrated factory using best commercial/military practices, and to achieve equal or better quality levels, reduced weight, and a decrease in cost when compared to the existing business and performance baseline. Data collected throughout the program was used by the C-17 SPO to determine if cost benefits are sufficient to warrant incorporation of revised business practices and the improved stabilizer into their program.

#### Status

*Active*

*Start date: June 1994*

*End date: December 1998*

#### Resources

*Project Engineer:*

*Ken Ronald*

*AFRL/MLMP*

*(937) 255-7278*

*Air Force Funded*

*Contractor:*

*Boeing Company*

### National Center for Manufacturing Science

(Page 15) Contract Number: F33615-96-C-5619 ALOG Number: 73

**Update** - The National Center for Manufacturing Science (NCMS) is a nonprofit research consortium of U.S. manufacturers, organized under the 1984 National Cooperative Research Act. It was designed to fund manufacturing research projects that would meet the needs of U.S. industry, including the U.S. machine tool industry, and promote the use of new technology in U.S. manufacturing companies. A major objective of the NCMS was to provide a focus for the cooperative efforts within industry, and to establish a research agenda to address the manufacturing needs of U.S. industries in a global economy. By offering effective leveraging of their resources, NCMS helped companies achieve both objectives. NCMS currently has a membership of two hundred companies which includes the Who's Who of American industry. The NCMS technical agenda is member driven and 90 percent of the technical projects are planned and performed by the membership companies. The benefits of this program include the promotion of research and technology transfer in manufacturing engineering in the United States. Development of a defense-driven, industry-led collaborative technology development agenda will have both broad application across Department of Defense weapon systems, contractors, and commercial industry and their supplier tiers, and have the capability of enhancing national security and the overall competitiveness of U.S. manufacturers.

#### Status

*Active*

*Start date: April 1996*

*End date: April 1999*

#### Resources

*Project Engineer:*

*Theodore Finnessy*

*AFRL/MLOP*

*(937) 255-4623*

*Air Force Funded*

*Contractor:*

*National Center for  
Manufacturing Science*

# Air Armament Decision Support Tool (AADST)

**Contract Number: F33615-96-D-5101/033**

## Statement of Need

The requirement is to assist the Armament Product Group Manager (APGM) War Gaming Cell with an Air Armament Decision Support Tool for Lean Munitions Sustainment. The goal is to meet the requirements of flexibility, responsiveness and power projection capability in interfacing the Combat Ammunition System (CAS) with a completed replenishment tool in preparation for further transitioning to the joint service Ammunition Management Standard System (AMSS).

## Approach

AADST provides an interface between the CAS system and other air armament decision support tools. The Air Force has successfully developed and fielded a deployable echelon of CAS, called CAS-D. At the same time, CAS echelons for the Ammunition Control Point at OO-ALC, called CAS-A, and an echelon for major commands, called CAS-C, are deployed and active. CAS-B (Base) is used in-garrison to track each munitions storage areas' stockpile. CAS-A is the item management based application that is addressed in this task. The approach is to focus initially on the USAF CAS interface, analysis (which includes support to war gaming activities) and then on joint service requirement exploration for the AMSS. The planned approach is: (A) Review both the CAS database structure and the air armament decision support tool database to determine the required format for SQL scripts so that data flow can be direct and seamless with the transmission of output between databases is to be in "read only" format. (B) Interface with the CAS testbed database resident at Maxwell AFB's Gunter Annex DISA Megacenters. Inquiries will be run through DODAC on DODIC and stock numbers. (C) Integrate the CAS database resident at Hill AFB. (D) Design and test these interfaces for quick turn-around (2 day) analysis capability.

## Benefits

Speed, range, flexibility, perspective, precision and lethality of air armament allow global reach with overwhelming combat power on relatively short notice. Air power is the decisive force in war as well as an economic force for exercising U.S. overseas presence at the lowest cost in resources and manpower. To capitalize on air armament's rapid responsiveness, the USAF must sustain high states of readiness at all times, and maintain the highest readiness state among America's services. The Office of the Armament Product Group Manager (APGM), ASC/WM, is the single focal point for USAF air armament, whose role is to provide realistic armament expectations /expertise to joint war games simulating future conflicts. The results of these war games highlight the need not only for present, but also future requirements of our national security strategy.

## Status

*Active*

*Start date: May 1998*

*End date: May 1999*

## Resources

*Project Engineer:*

*Mr. Michael Baker*

*AFRL/MLMA*

*(937) 255-3920 ext. 399*

*Air Force Funded*

*Contractor:*

*Decision Sciences*

*Incorporated*

*JDMTP Subpanel:*

*Advanced Industrial*

*Practices*

# Lean Suppliers Integration Demonstration (LSID)

Contract Number: F33615-96-D-5101/037    ALOG Number: 1623

## Statement of Need

The requirement is to demonstrate the precepts of lean thinking and associated value from supplier activity. Approximately seventy percent of the cost of a system can be traced to the costs directly associated with the chain of suppliers of system components and this concept is known as the "value chain" in lean thinking. Capability, quality, and cost are not just results of design alone but are derived from the ability to transfer design into hardware that is capable of performing to expectations. Tools such as LSID to assist in the enabling advancements in lean manufacturing are paramount to the future of manufacturing.

## Approach

There are two primary thrusts within the Lean Supplier Integration concept. The first is the Real-Time Tracking and Information System, and the second is the Presentation and Simulation System. LSID uses On-Line Analytical Processing (OLAP) to provide the seamless transfer of information from the supplier to a prime database repository. The prime database repository thus becomes the common database of information. OLAP transfers information needed for presenting and simulating the total flow process of a network of subcontractors supplying components to a prime manufacturer. LSID can provide for status information, choke-point analysis, and quality representation of data collection. In addition, LSID provides an overall status of manufacturing progress, production analysis from current period to end of contract, excess parts accumulation, shift and capacity analysis, and other important factors of the overall production network. LSI is an enterprise model, incorporating SQL database technology, and demonstrating multiple user capability. LSID has thus far successfully completed an actual hardware/software demonstration on-site in a supplier's and vendor's plant using both the internet and supplier intranet.

## Benefits

LSID demonstrates total value chain visibility, providing for seamless and near real-time communication, tracking information of value chain vendors, simulation capability of the probable results of changes, improvements, quantity variations, and other "What-If" options for technology transfer to industry for lean manufacturing. As end-to-end demonstration of the use of existing leading edge OLAP technology, simulation capability, tracking capability, and seamless data interchange for improvement of value chain manufacturing, LSID integrates Lean Aerospace Initiative concepts.

## Status

*Active*

*Start date: September 1998*

*End date: September 1999*

## Resources

*Program Manager:*

*Michael Baker*

*AFRL/MLMA*

*(937) 255-3920 ext. 399*

*Air Force Funded*

*Contractor: Decision Sciences  
Incorporated*

*JDMTP Subpanel:  
Advanced Manufacturing  
Enterprise*

## Active Matrix Liquid Crystal Display Manufacturing Technology

(Page 21) Cooperative Agreement Number: MDA972-93-2-0016 ALOG Number: 1172

### Technical Report Number: In Progress

The Department of Defense has identified world-class active matrix liquid crystal display (AMLCD) manufacturing capability as "defense critical" based on the needs of the F-22 and other high-priority aircraft cockpit applications. In order to demonstrate the establishment of this critical manufacturing capability, a pilot manufacturing demonstration facility was established and demonstrated on current technology products. The primary purpose of this program was the design, construction and operation of a world-class Pilot Demonstration Facility (PDF) for high yield productions of AMLCDs. The PDF is capable of providing a sufficient number of high quality displays to meet a substantial portion of the government's needs through at least the end of the decade. This research will result in the availability of competitively-priced flat panel AMLCDs from a U.S. manufacturer, and the establishment of a center for the development of manufacturing techniques necessary for the next generation (e.g. polysilicon and other) display technology.

### Status

*Complete*

*Start date: August 1993*

*End date: August 1998*

### Resources

*Project Engineer:*

*Tony Bumbalough*

*AFRL/MLME*

*(937) 255-2644*

*DARPA Funded*

*Contractor:*

*Optical Imaging Systems Inc.,*

## Development of a Low Cost Environmentally Benign All-Sputtered Fabrication of Thin-Film Transistors for Active Matrix Liquid Crystal Displays

(Page 27) Contract Number: F33615-94-C-4446 ALOG Number: 1281

### Technical Report Number: In Progress

Active matrix liquid crystal displays (AMLCDs) are the cockpit designer's choice for replacing CRTs since they are sunlight readable with full color capability. In addition, AMLCDs provide a large viewing area with small instrument depth and do not fail catastrophically rendering the display inoperable. The active matrix liquid crystal technology must be developed in the United States so that the displays required by the military are available from domestic sources. These programs, under DARPA/MANTECH auspices, will develop the manufacturing equipment necessary to establish the domestic manufacturing capability for large area active matrix liquid crystal displays.

### Status

*Complete*

*Start date: September 1994*

*End date: October 1998*

### Resources

*Project Engineer:*

*Charles Wagner*

*AFRL/MLME*

*(937) 255-2461*

*DARPA Funded*

*Contractor:*

*Intevac*

## Completed Projects

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### **Development of an Adaptive Laser Imaging Tool for Large Area Flat Panel Display Mask Generation and Maskless Patterning**

(Page 28) Contract Number: F33615-94-C-4441 ALOG Number: 1282

**Technical Report Number: In Progress**

The active matrix liquid crystal technology must be developed in the United States so that the displays required by the military are available from domestic sources. These programs, under DARPA/MANTECH auspices, will develop the manufacturing equipment necessary to establish the domestic manufacturing capability for large area active matrix liquid crystal displays. The primary objective of this program is a laser imaging system, the Adaptive Laser Imaging Tool (ALIT), capable of patterning 5 mm features over a 24" x 24" glass flat panel display or photomask substrate. The development of the Adaptive Laser Imaging Tool will reduce the need for complex array of capital equipment needed to support large area steppers. An integral automatic optical inspection module will permit in-situ layer-to-layer overlay measurement and correction for flat panel displays.

#### **Status**

*Complete*

*Start date: July 1994*

*End date: March 1998*

#### **Resources**

*Project Engineer:*

*Charles Wagner*

*AFRL/MLME*

*(937) 255-2461*

*DARPA Funded*

*Contractor:*

*Polyscan Inc.*

### **Development of Co-Optimized Rapid Thermal Process and a Silicon Deposition Solid-Phase Crystallization Process for Cost Reduced LCD Manufacturing**

(Page 30) Contract Number: F33615-94-C-4449 ALOG Number: 1256

**Technical Report Number: In Progress**

The active matrix liquid crystal technology must be developed in the United States so that the displays required by the military are available from domestic sources. These programs will develop the manufacturing equipment necessary to establish the domestic manufacturing capability for large area active matrix liquid crystal displays (AMLCDs). The primary objective of this program is to co-optimize the rapid thermal and amorphous silicon deposition processes to yield a solid phase crystallized polysilicon thin film that crystallizes at lower temperatures and is higher in mobility than what is currently available. The specific tasks of the experimentation are to enumerate the a-Si deposition variables along with the rapid thermal processor (RTP) parameters which will contribute to lowering the temperature of RTP solid phase crystallization.

#### **Status**

*Complete*

*Start date: September 1994*

*End date: October 1998*

#### **Resources**

*Project Engineer:*

*Charles Wagner*

*AFRL/MLME*

*(937) 255-2461*

*DARPA Funded*

*Contractor:*

*Intevac*

## EcoBoard: A Tool for the Design of Green Printed Circuit Boards and Assemblies

(Page 31) Cooperative Agreement Number: F33615-95-2-5548 ALOG Number: 1388

**Technical Report Number: In Progress**

The EcoBoard product is an attempt to address key material and process environmental concerns early in the PCB and PCB assembly development process. The applicability of EcoBoard in the design of real electronic systems and components and the integration of environmental considerations into existing design practices was established through significant demonstrations. EcoBoard solves the problem of scope and complexity of environmental analyses, making it practical for designers to assess environmental impact. The critical tradeoff in an environmental analysis is between the time and cost of a comprehensive, detailed assessment and the uncertainty introduced when parts of the life cycle impact are approximated. EcoBoard solves this problem by assessing the strength of links between design choices and environmental impacts.

### Status

*Complete*

*Start date: August 1995*

*End date: October 1998*

### Resources

*Project Engineer:*

*Ron Bing*

*AFRL/MLME*

*(937) 255-2461*

*DARPA Funded*

*Contractor:*

*Science Applications*

*International Corp*

## High Performance Underfill Encapsulant for Low-Cost Flip Chip

(Page 36) Contract Number: F33615-96-C-5117 ALOG Number: 1520

**Technical Report Number: In Progress**

Direct flip chip attachment of integrated circuits (IC) holds some inherent advantages over conventional packaging of electronics in both defense and commercial applications, such as smaller form factor and higher performance. Overall, there is a pervasive need for better underfill materials and flip chip related cleaning and assembly processes that can enhance the reliability, manufacturability, and repairability of direct chip attach structures. The underfill encapsulant is critical to the reliability of flip chip solder joint interconnects, especially with the flip chip on organic boards, due to the thermal coefficient of expansion (TCE) mismatch between the silicon IC and the organic substrate.

### Status

*Complete*

*Start date: September 1996*

*End date: September 1998*

### Resources

*Project Engineer:*

*Charles Wagner*

*AFRL/MLME*

*(937) 255-2461*

*Air Force Funded*

*Contractor:*

*National Semiconductor*

## Improved Emissive Coatings for Super High Efficiency Color Alternating-Current Plasma Display Panels

(Page 37) Contract Number: F33615-94-C-4408 ALOG Number: 1207

**Technical Report Number: In Progress**

The primary objective of this program was to improve, in an alternating-current plasma display panel, the efficiency of the emissive layer (which produces secondary electrons from the bombardment of incident plasma ions) potentially by up to one to two orders of magnitude. A specific objective of this program was to improve the material characteristics of the emissive/protective layer.

### Status

*Complete*

*Start date: September 1994*

*End date: April 1998*

### Resources

*Project Engineer:*

*Charles Wagner*

*AFRL/MLME*

*(937) 255-2461*

*DARPA Funded*

*Contractor:*

*Photonics Imaging*

# Completed Projects

## Infrared Focal Plane Array Flexible Manufacturing

(Page 38) Contract Number: F33615-93-C-4320 ALOG Number: 1173

**Technical Report Number: In Progress**

The Infrared Focal Plane Array Flexible Manufacturing (IRFPA/FM) program is a multi-year program to address Infrared (IR) sensor affordability by developing a manufacturing facility capable of producing multi-sensor products simultaneously while significantly reducing development and production costs. Key to the affordability of the product was to create a production line flexible enough to produce military and commercial products on the same line. Other affordability approaches taken were automated design tooling development, automated factory control, automated tooling and process development, an \$11 million capital investment made by the contractor in new equipment, standardization of sub-components for dewers to allow reduced parts inventory, and new automated assembly tools for dewers. In addition, development of new technologies were undertaken, significantly improving available sensor performance. These new products were then integrated into the factory. At the beginning of this program, 240X1 arrays, the first second generation products, were available to military users. Now, 480X640 arrays, the first third generation sensors, are available for ultra sensitive target detection.

### Status

*Complete*

*Start date: September 1993*

*End date: November 1998*

### Resources

*Project Engineer:*

*P. Michael Price*

*AFRL/MLME*

*(937) 255-2461*

*DARPA Funded*

*Contractor:*

*Raytheon Company*

## Integrating People, Products, Processes

(Page 40) Contract Number: F33615-95-C-5546 ALOG Number: 1360

**Technical Report Number: In Progress**

This program challenges industry to demonstrate radically innovative concepts in the tactical missile sector to achieve cost and cycle time savings comparable to those that have been achieved by world-class commercial manufacturers in other sectors. This effort was one of four Defense Advanced Research Projects Agency (DARPA) sponsored programs under the Affordable Multi-Missile Manufacturing program.

### Status

*Complete*

*Start date: June 1995*

*End date: January 1998*

### Resources

*Project Engineer:*

*Charles Wagner*

*AFRL/MLME*

*(937) 255-2461*

*DARPA Funded*

*Contractor:*

*Texas Instruments/Hughes  
Missile Systems*

## Low Cost Electrode Fabrication Process for High Definition System Color Flat Panel Displays

(Page 44) Contract Number: F33615-94-C-4411 ALOG Number: 1208

**Technical Report Number: In Progress**

This project developed a low-cost, high resolution, electrode fabrication process based on selective electroplating and/or electroless deposition using electrodes or vacuum deposited seed layer. This new fabrication process has a very low manufacturing cost, eliminates thick film pad printing and firing, and is compatible with ultra-high resolution color product and FCOG packaging.

### Status

*Complete*

*Start date: September 1994*

*End date: May 1998*

### Resources

*Project Engineer:*

*Charles Wagner*

*AFRL/MLME*

*(937) 255-2461*

*DARPA Funded*

*Contractor:*

*Photonics Imaging*

## Low Cost Flip Chip

(Page 46) Cooperative Agreement Number: MDA972-95-3-0031 ALOG Number: 1602

Technical Report Number: In Progress

This program was structured around a vertically integrated consortium led by National Semiconductor Corporation. Collectively, these members possess the resources to put in place a fabrication capability for low cost flip DCA, ranging from chip design through end product assembly. Equally important, they command a wide range of military and commercial markets. The team drove technology development and the economies of high-volume manufacturing to reduce direct chip attach costs by attempting to build five different products using this technology. Results were mixed and are available in the final report.

### Status

*Complete*

*Start date: August 1995*

*End date: March 1998*

### Resources

*Project Engineer:*

*Charles Wagner*

*AFRL/MLME*

*(937) 255-2461*

*TRP Funded*

*Contractor:*

*National Semiconductor Corporation*

## Low Cost, High Performance, Low Temperature Co-fired Ceramic-on-Metal Substrates for Mixed Signal Modules

(Page 47) Cooperative Agreement Number: F33615-96-2-5105 ALOG Number: 1528

Technical Report Number: In Progress

This program developed the capability to fabricate buried passive components directly into low temperature co-fired ceramic (LTCC) substrates, developed design kits for the buried component technology and to transfer that technology to a high volume substrate manufacturer. By developing the technology to incorporate buried passive devices and filters directly within a multi-layer LTCC-M substrate, very high mixed signal device densities can be achieved in very small form factor packages.

### Status

*Complete*

*Start date: September 1996*

*End date: September 1998*

### Resources

*Project Engineer:*

*Walt Spaulding*

*AFRL/MLME*

*(937) 255-2461*

*DARPA Funded*

*Contractor:*

*David Sarnoff Research Center*

## Manufacturing Technology for Tactical Grade Interferometric Fiber Optic Gyroscopes

(Page 50) Contract Number: F33615-93-C-4321 ALOG Number: 405

Technical Report Number: In Progress

The objective of this program was to establish the manufacturing processes and supplier base required to produce tactical grade Interferometric Fiber Optic Gyroscopes (IFOGs) at less than \$1,000 per axis, with a goal of \$500 per axis. Benefits included a greater than 90 percent cost reduction of IFOGs for applications in aircraft navigation and missile guidance subsystems; the establishment of improved and controlled manufacturing processes; and enhancement of the IFOG industrial base.

### Status

*Complete*

*Start date: September 1993*

*End date: April 1998*

### Resources

*Project Engineer:*

*Persis Elwood*

*AFRL/MLME*

*(937) 255-2461*

*Air Force Funded*

*Contractor:*

*Litton Corporation*

## Completed Projects

### Precision Thick Film Technology for 100 Percent Yield of Large Area High Resolution Color Alternating-Current Plasma Display Panels

(Page 54) Contract Number: F33615-94-C-4406 ALOG Number: 1206

Technical Report Number: In Progress

The primary objective of this program was to develop a low-cost precision thick film screen printing manufacturing process capable of producing high resolution, full color alternating-current plasma display panels (AC-PDPs) with a yield of 100 percent. This program developed an integrated screen printing manufacturing process capable of achieving both large area print uniformity and thickness control in a flat-panel display (FPD) manufacturing operation. The technology developed is generic in nature and will benefit other FPD/electronic devices.

**Status**

*Complete*

*Start date: September 1994*

*End date: December 1997*

**Resources**

*Project Engineer:*

*Charles Wagner*

*AFRL/MLME*

*(937) 255-2461*

*DARPA Funded*

*Contractor:*

*Photonics Imaging*

### Real-Time FT-IR Diagnostics and Control of Semiconductor Fabrication

(Page 56) Contract Number: F33615-95-C-5545 ALOG Number: 1426

Technical Report Number: In Progress

Recent developments in microelectronics manufacturing emphasized a high flexibility concept, including single wafer processing in cluster tools, sensor-based, closed loop process control, and factory automation. Although these concepts have already been demonstrated, in order for the industry to fully benefit from the implementation of these concepts, continuing advancements are needed in the area of modeling for real-time process control. This project verified models with actual manufacturing processes, modified models as necessary, and planned for the implementation of the models into production.

**Status**

*Complete*

*Start date: September 1995*

*End date: September 1998*

**Resources**

*Project Engineer:*

*P. Michael Price*

*AFRL/MLME*

*(937) 255-2461*

*SBIR Funded*

*Contractor:*

*Advanced Fuel Research Inc.*

## Real-Time Whole Wafer Thermal Imaging for Semiconductor

(Page 57) Contract Number: F33615-97-C-5134 ALOG Number: 1533

Technical Report Number: In Progress

This project developed a fast polarimetric imaging radiometer capable of producing whole wafer temperature maps with accuracy (even when the emissivity may be drifting), temperature dependence and spatially varying.

### Status

*Complete*

*Start date: April 1997*

*End date: December 1997*

### Resources

*Project Engineer:*

*Ron Bing*

*AFRL/MLME*

*(937) 255-2461*

*SBIR Funded*

*Contractor:*

*On-Line Technologies*

## Rugate Coating Producibility

(Page 59) Contract Number: F33615-93-C-5317 ALOG Number: 411

Technical Report Number: In Progress

The Rugate Coating Producibility task established a production capability for rugate coatings that demonstrated enhanced yield, increased throughput, process scalability, and reduced costs. In addition, emphasis was placed on transferring the in-situ monitoring techniques and process methodology used to manufacture rugate coatings to other manufacturers of optical, microelectronic, microwave, and optoelectronic thin film devices.

### Status

*Complete*

*Start date: September 1993*

*End date: December 1997*

### Resources

*Project Engineer:*

*P. Michael Price*

*AFRL/MLME*

*(937) 255-2461*

*Air Force Funded*

*Contractor:*

*Hughes Company*

## Solder Jetting for Electronics Manufacturing

(Page 62) Cooperative Agreement Number: F33615-97-2-5120 ALOG Number: 1526

Technical Report Number: In Progress

This effort developed advanced solder deposition equipment for the electronics manufacturing industry. The basis for solder jet printing is demand-mode ink-jet printing. A droplet is created only when it is desired in demand-mode systems. Demand-mode ink-jet printing systems produce droplets that are approximately equal to the orifice diameter of the droplet generator. Solder jet-based equipment will produce and place molten solder droplets, 25-125  $\mu\text{m}$  in diameter, at rates up to 200 per second, making it suitable for high throughput, low cost packaging and assembly of the high density commercial and military electronics.

### Status

*Complete*

*Start date: March 1997*

*End date: September 1998*

### Resources

*Project Engineer:*

*Charles Wagner*

*AFRL/MLME*

*(937) 255-2461*

*Air Force Funded*

*Contractor:*

*Microfab Technologies Inc.*

# Completed Projects

## Strategic Packaging for Single & Multi-Chip Modules Using Very Small Peripheral Arrays

(Page 63) Cooperative Agreement Number: F33615-96-2-5110 ALOG Number: 1468

Technical Report Number: In Progress

This program demonstrated the viability of very small peripheral arrays and ensured the reliability of the technology for use in applications that require a high I/O pin count. The VSPA technology is an alternative packaging concept that reduces the board space requirements and can be easily soldered in place as an alternative to more traditional plastic packages. This technology provides a high I/O pin count in a small space while handling the inherent thermal load efficiently.

### Status

*Complete*

*Start date: September 1996*

*End date: March 1998*

### Resources

*Project Engineer:*

*Charles Wagner*

*AFRL/MLME*

*(937) 255-2461*

*DARPA Funded*

*Contractor:*

*Panda Project*

## Whole Wafer Thermal Measurement by Means of Laser Ultrasound

(Page 65) Contract Number: F33615-97-C-5133 ALOG Number: 1535

Technical Report Number: AFRL-ML-WP-TR-1998-4058

This project developed an economical thermal sensor capable of measuring in-situ the temperature distribution in semiconductor wafers. An accurate and reliable in-situ whole-wafer temperature measurement technique will have an immediate commercial market in temperature monitoring and control for a wide variety of thermal processing technologies such as rapid thermal processing, molecular beam epitaxy and metallo-organic chemical vapor deposition.

### Status

*Complete*

*Start date: April 1997*

*End date: December 1997*

### Resources

*Project Engineer:*

*Ron Bing*

*AFRL/MLME*

*(937) 255-2461*

*SBIR Funded*

*Contractor:*

*Karta Technology Inc.*

## Zero Dump Electroplating Process Development

(Page 66) Contract Number: F33615-95-C-5506 ALOG Number: 1342

Technical Report Number: AFRL-ML-WP-TR-1998-4066

This project developed and demonstrate an electroplating process that can achieve high quality coatings and precise property control without the need for additives in the plating baths. High quality coatings and zero additives implies zero dumping. This precise property control is achieved by using a periodic current (PC) plating process to obtain uniform electrocoatings. Applications of this technique to the printed circuit board manufacturing and metal finishing industries eliminates the need for additives in their electroplating activities for both the Department of Defense and commercial applications.

### Status

*Complete*

*Start date: February 1995*

*End date: December 1997*

### Resources

*Project Engineer:*

*Ron Bing*

*AFRL/MLME*

*(937) 255-2461*

*DARPA Funded*

*Contractor:*

*Physical Sciences Inc.*

## Development of Affordable Optic Chips

(Page 25) Contract Number: F33615-97-C-5124 ALOG Number: 1538

**Update** - The overall goal of this effort is to reduce the cost of pigtailed integrated optic chips (IOCs), which are a key component used in fiber optic gyros (FOGs), to less than \$100 in large volume production (6000 inertial measurement units (IMUs) per year). Fiber optic gyros have numerous applications in both the commercial and military markets, primarily in the area of navigation (airplanes and ships).

### Status

*Active*

*Start date: March 1997*

*End date: March 1999*

### Resources

*Project Engineer:*

*Ron Bing*

*AFRL/MLME*

*(937) 255-2461*

*SBIR Funded*

*Contractor:*

*Ramar Corp*

## Instrument for Rapid Quantitative and Nondestructive Wafer Evaluation

(Page 39) Contract Number: F33615-96-C-5108 ALOG Number: 1461

### Technical Report Number:

The objective of this Phase II Small Business Innovation Research (SBIR) project was to develop a rapid in-process wafer surface defect measurement system that can inspect large surface areas in a non-intrusive, non-contact manner to determine the quality of wafer surface. The approach was to take the Phase I breadboard of the heterodyne laser optical scanning scatterometer and refine it into a commercial product through extensive requirements definition, system design and prototyping and design of experiments evaluation.

### Status

*Active*

*Start date: July 1996*

*End date: January 1999*

### Resources

*Project Engineer:*

*Walt Spaulding*

*AFRL/MLME*

*(937) 255-2461*

*SBIR Funded*

*Contractor:*

*Sentec Corporation*

## Light Detection and Ranging (LIDAR) Wind Sensor Manufacturability

(Page 42) Contract Number: F33615-97-C-5145 ALOG Number: 1498

**Update** - The program's objective is to: enable the transition of an eyesafe Light Detection and Ranging (LIDAR) wind sensor transceiver to a robust, production ready design which can be employed in numerous applications; to leverage the science and technology Integrated Product and Process Development (IPPD) training program; to demonstrate the application of Design for Manufacturing (DFM) and Rapid Prototyping in the transition of the LIDAR system to production; and to address affordability early in the lifetime of the system by application of IPPD principles.

### Status

*Active*

*Start date: August 1997*

*End date: August 2000*

### Resources

*Project Engineer:*

*Walt Spaulding*

*AFRL/MLME*

*(937) 255-2461*

*Air Force Funded*

*Contractor:*

*Coherent Technologies Incorporated*

# Active Projects

## Manufacturing Technology for Multi-Band Gap Solar Cells

(Page 48) Contract Number: F33615-95-C-5561 ALOG Number: 1465

**Update** - The objective of this program is to produce monolithic III-V multi-junction solar cells grown on germanium substrates for space applications. The program escalated yield, increased efficiency, and reduced cost by improving the manufacturing processes of these cells.

### Status

*Active*

*Start date: September 1995*

*End date: March 1999*

### Resources

*Project Engineer:*

*P. Michael Price*

*AFRL/MLME*

*(937) 255-2461*

*Air Force Funded*

*Contractor:*

*Spectrolab Inc.*

## Manufacturing Technology for Multi-Band Gap Solar Cell Array

(Page 49) Contract Number: F33615-95-C-5508 ALOG Number: 1278

**Update** - The objective of this program is to enable the production of monolithic III-V multi-junction solar cells grown on germanium substrates for space applications. The goal is to improve the yield and efficiency, and reduce the cost of the manufacturing processes used in producing these cells while increasing the size of the solar cells to the sizes available in single junction solar cells.

### Status

*Active*

*Start date: September 1995*

*End date: March 1999*

### Resources

*Project Engineer:*

*P. Michael Price*

*AFRL/MLME*

*(937) 255-2461*

*Air Force Funded*

*Contractor:*

*TECSTAR Corporation*

## Prototype Development of a Very Large Area, High Performance Microlithography Tool

(Page 55) Contract Number: F33615-92-C-5805 ALOG Number: 445

**Update** - The specific objective of this program is to construct a full-scale prototype of a large area microlithography tool capable of imaging glass substrates up to 500 mm x 600 mm square at approximately threefold increase in imaging throughput rates as compared to any currently available large area microlithography tool.

### Status

*Active*

*Start date: February 1992*

*End date: January 1999*

### Resources

*Project Engineer:*

*Charles Wagner*

*AFRL/MLME*

*(937) 255-2461*

*DARPA Funded*

*Contractor:*

*MRS Technology*

# F-22 Radar Subarray Manufacturing Process Improvements

Contract Number: F33615-97-C-5159    ALOG Number: 1605

## Statement of Need

The current method of assembling APG-77 F-22 Radar subarrays requires the use of manually soldered flex circuit interconnects to make the numerous radio frequency, digital, and direct current connections between the components that make up the subarray. This flex circuit interconnect process is costly, labor intensive, and has an unacceptably low first pass yield. The objective of this program is to improve the first pass yield, and reduce the cost of the electrical interconnects between the components of the F-22 Radar antenna subarray.

## Approach

The approach will be to improve the ribbon bond interconnect process currently used in the assembly of radar circulators and apply it to the assembly of radar subarrays. Processes must be improved to enable reliable, repeatable ribbon bonds to be formed at low working temperatures and to incorporate that process into an automated assembly work cell.

## Benefits

The objective is to improve the manufacturing assembly yield and decrease the cost of the APG-77 radar subarray. This will be accomplished by replacing thousands of costly and labor intensive flex circuit interconnects with improved automated ribbon bonds.

## Status

*Active*

*Start date: January 1998*

*End date: September 1999*

## Resources

*Project Engineer:*

*Walt Spaulding*

*AFRL/MLME*

*(937) 255-2461*

*SBIR Funded*

*Contractor:*

*Northrop Grumman*

*Corporation*

*JDMTP Subpanel:*

*Electronics*

# Completed Projects

## Collaborative University/Industry Manufacturing Research

(Page 77-79) Grant Number: numerous    ALOG Number: 1263, 1411-1414

Technical Report Number: Numerous

The objective of this joint National Science Foundation/Manufacturing Technology funded effort was to stimulate and expand research of Manufacturing Technology using collaborative research among university and industry to create and accelerate the insertion of new technologies into the Department of Defense, aerospace manufacturing and the supporting industrial base. ManTech selected the highest ranked prioritized relevant proposals and funded or co-funded with NSF.

The following grants were awarded as part of the program:

**Robust Scheduling and Diagnostics Using Simulation-Based Optimization**

(97-1) Georgia Tech

**Optimal Pre-Stressing Surfaces by Superfinish Hard Turning for Maximum Fatigue Life**

(97-2) Purdue University

**Enterprise Design: Integrating Product, Process and Organization**

(96-1) Georgia Tech

**The Effect of Pre-Existing Residual Stress in Dry Superfinish Hard Turning**

(96-2) Purdue University

**A Distributed Decision Framework Integrating Manufacturing Planning and Supply Chain Management**

(96-3) Lehigh and University of Pennsylvania

**Supply Chain Management for Electronics Manufacturing with Product Recovery and Remanufacturing**

(96-4) Purdue University

**Rapid Design and Analysis of Advanced Manufacturing Systems**

(96-5) University of Florida

**Optimal Design of Bulk Forming Processes**

(96-6) Rensselaer Polytechnic Institute

**A Responsive Process Planning System in Agile Manufacturing**

(96-7) University of Missouri

**A Methodology for Promoting the Design & Justification of Innovative Solutions to Flexible Manufacturing Problems in Traditional Factories**

(95-1) New Jersey Institute of Technology

**Life Cycle Costs of Manufacturing Activities and Technological Innovation**

(95-2) Texas A&M University

**Flexible Accounting Systems in Dynamic Manufacturing Environments**

(95-3) Iowa State University

**Innovation, Implementation, and Costs**

(95-4) Tennessee Technological University

**Decision Making with Incomplete Information in an IPPD Enterprise - A Management Decision Tool for Cost Modelling and Affordability Applications**

(95-5) Florida A&M and Florida State University

### Status

*Complete*

*Start date: September 1995*

*End date: September 1998*

### Resources

*Project Engineer:*

*David Judson*

*AFRL/MLMS*

*(937) 255-7371*

## Activity-Based Costing for Agile Manufacturing Control

(Page 67) Contract Number: F33615-95-C-5516 ALOG Number: 1361

Technical Report Number: In Progress

Activity-based costing assigns job costs based on the actual use of firm resources. This is often seen as only a "big" company solution. Very few small companies have implemented activity based costing in conjunction with a shift toward agile manufacturing. This project's objective was to determine and quantify the costs and benefits of using activity-based costing in a small company environment to support an agile manufacturing strategy.

### Status

*Complete*

*Start date: January 1995*

*End date: March 1998*

### Resources

*Project Engineer:*

*Cliff Stogdill*

*AFRL/MLMS*

*(937) 255-7371*

*DARPA Funded*

*Contractor:*

*Industrial Technology*

*Institute*

## Context Integrated Design

(Page 80) Contract Number: F33615-96-C-5614 ALOG Number: 1446

Technical Report Number: AFRL-ML-WP-TR-1998-4072

This program provided mechanisms for information search, retrieval and filtering, as well as capturing design history. Context Integrated Design (CID) realizes participatory design methodologies through extension of the concepts of the electronic engineering notebook and agent-based engineering collaboration. The CID environment enhances information discovery, evaluation and incorporation in a geographically distributed design environment.

### Status

*Complete*

*Start date: March 1996*

*End date: February 1998*

### Resources

*Project Engineer:*

*James Poindexter*

*AFRL/MLMS*

*(937) 255-7371*

*DARPA Funded*

*Contractor:*

*Lockheed Martin*

*Corporation*

## Definition of Generic Production Cost Model

(Page 84) Contract Number: F33615-97-C-5127 ALOG Number: 1545

Technical Report Number: In Progress

The primary objective of this Phase I Small Business Innovation Research (SBIR) project was to create the generic core of a computer-based production cost model (PCM) to support systems program offices in the attainment of several acquisition reform initiatives. The PCM supports the information requirement of costs as an independent variable (CAIV), including aggressive cost goals, trade-off analyses, and incentive measurements. After developing the structural and performance criteria for the PCM, the criteria was used in completing the PCM's conceptual design.

### Status

*Complete*

*Start date: March 1997*

*End date: December 1997*

### Resources

*Project Engineer:*

*Wallace Patterson*

*AFRL/MLMS*

*(937) 656-9220*

*SBIR Funded*

*Contractor:*

*Wallace & Company*

# Completed Projects

## Development of Adaptive Modeling Language for Knowledge-Based Systems

(Page 85) Contract Number: F33615-96-C-5606 ALOG Number: 1476

Technical Report Number: In Progress

This effort developed an adaptive modeling language for domain-specific, knowledge-based engineering in the electromechanical design process. The resulting integrated CAD tools and methods including process knowledge reduce product development cycle time, increase design reuse and capture design functionality. The end system is supported by commercial CAD tools that have the capability of being applied to DoD and commercial electromechanical systems.

### Status

*Complete*

*Start date: March 1996*

*End date: October 1998*

### Resources

*Project Engineer:*

*Alan Winn*

*AFRL/MLMS*

*(937) 255-4623*

*DARPA Funded*

*Contractor:*

*Lockheed Martin*

*Corporation*

## E-3 AWACS Synchronizer Remanufacture Using VHDL

(Page 86) Contract Number: F33615-97-C-5140 ALOG Number: 1552

Technical Report Number: In Progress

The objective of this project was to demonstrate an improved process for the cost and time effective management of electronic component obsolescence. This proof of concept project serves as a model for further implementations at other defense industry facilities.

### Status

*Complete*

*Start date: August 1997*

*End date: November 1998*

### Resources

*Project Engineer:*

*Bill Russell*

*AFRL/MLMS*

*(937) 255-7371*

*Air Force Funded*

*Contractor:*

*Northrop Grumman*

*Corporation*

## Fast and Flexible Communication of Engineering Information in the Aerospace Industry

(Page 91) Contract Number: F33615-94-C-4429 ALOG Number: 1251

Technical Report Number: In Progress

This project aimed to improve key processes in the aircraft industry by following a bottom-up process. At the same time, it deepened understanding of the top-level concepts of agility. Aerospace components and assemblies are procured through a complex web of parts and tooling suppliers. Crucial information necessary for part fitup and product performance can be lost in this web, necessitating extensive problem-solving activities. Speed and flexibility can be improved by examining both the problem-solving processes and the underlying customer-supplier relations.

### Status

*Complete*

*Start date: June 1994*

*End date: May 1998*

### Resources

*Project Engineer:*

*George Orzel*

*AFRL/MLMS*

*(937) 656-9219*

*DARPA Funded*

*Contractor:*

*Massachusetts Institute*

*of Technology*

## Fast and Flexible Design and Manufacturing Systems for Automotive Components and Sheet Metal Parts

(Page 92) Contract Number: F33615-94-C-4428 ALOG Number: 1250

### Technical Report Number: In Progress

Fast and flexible business activities are characterized by: organizing for change, virtual partnerships, valuing knowledge and skills, and enriching the customer. This project deepened understanding of these characteristics by studying specific assemblies built for and obtained from other companies. The methods used were process mapping to identify crucial transactions between people and companies, linking transactions to clusters of specific engineering data called features, identifying transactions that do not add value, identifying and inserting missing transactions, and speeding up the processes by providing computer tools and database access that connect people and their transactions to engineering features.

#### Status

*Complete*

*Start date: June 1994*

*End date: May 1998*

#### Resources

*Project Engineer:*

*George Orzel*

*AFRL/MLMS*

*(937) 656-9219*

*DARPA Funded*

*Contractor:*

*Massachusetts Institute of Technology*

## Improving Manufacturing Processes in Small Manufacturing Enterprises

(Page 95) Cooperative Agreement Number: F33615-94-2-4418 ALOG Number: 1212

### Technical Report Number: In Progress

To create the ability in small manufacturers to quickly respond to national security needs when an emergency arises, improvements in manufacturing processes must occur. The primary objective of this project was to provide a productivity improvement waste reduction technique called the Manufacturing Improvement Process (MIP) to 36 small manufacturers in central Minnesota over a period of three years.

#### Status

*Complete*

*Start date: March 1994*

*End date: March 1998*

#### Resources

*Project Engineer:*

*Cliff Stogdill*

*AFRL/MLMS*

*(937) 255-7371*

*DARPA Funded*

*Contractor: Higher Education*

*Manufacturing Process Applications Consortium*

## Integrated Product/Process Development (IPPD) Simulation Model

(Page 98) Contract Number: F33615-97-C-5129 ALOG Number: 1542

### Technical Report Number: AFRL-ML-WP-TR-1998-4032

The focus of this general topic was to allow opportunities for major breakthroughs in the areas of: Composites Processing & Fabrication, Electronics Processing & Fabrication, Metals Processing & Fabrication, Advanced Industrial Practices, and Manufacturing & Engineering Systems. The objective was to develop a methodology for developing a dynamic simulation model of the Integrated Product/Process Development (IPPD) process.

#### Status

*Complete*

*Start date: May 1997*

*End date: November 1997*

#### Resources

*Project Engineer:*

*Cliff Stogdill*

*AFRL/MLMS*

*(937) 255-7371*

*SBIR Funded*

*Contractor:*

*Decision Dynamics Incorporated*

# Completed Projects

## JSF Manufacturing Capability Assessment Tool Set

(Page 101) Contract Number: F33615-95-C-5527    ALOG Number: 1340

**Technical Report Number: In Progress**

The objective of this program was to develop and implement an approach which defines the format and content of Joint Strike Fighter (JSF) information used in the manufacturing capability requirements (MCR) process, computerize the MCR assessment methodology, and extend the process.

**Status**

*Complete*

*Start date: April 1995*

*End date: April 1998*

**Resources**

*Project Engineer:*

*Theodore Finnessy*

*AFRL/MLOP*

*(937) 255-4623*

*JSF Funded*

*Contractor:*

*General Research Corporation*

## Laser-Based Reverse Engineering & Concurrent Systems

(Page 103) Contract Number: F33615-96-C-5616    ALOG Number: 1453

**Technical Report Number: In Progress**

Structural parts of the Department of Defense fleet of aircraft are in constant need of repair or replacement. The current practice involves several months, with a Computer Aided Design (CAD) expert, measuring the original part and creating a three-dimensional CAD model of it so that the replacement part can be machined. This project developed a process in which laser scanners are used to reverse engineer the structural parts into CAD models which are then integrated with an existing concurrent engineering system to remanufacture these parts.

**Status**

*Complete*

*Start date: February 1996*

*End date: November 1998*

**Resources**

*Project Engineer:*

*David Slicer*

*AFRL/MLMS*

*(937) 255-7371*

*Air Force Funded*

*Contractor:*

*Florida International*

*University*

## Manufacturing Simulation Driver

(Page 105) Contract Number: F33615-96-C-5609    ALOG Number: 1481

**Technical Report Number: In Progress**

The overall objective of the Rapid Design Exploration and Optimization (RaDEO) program is to develop engineering tools and information integration capabilities that could be used to evaluate an order of magnitude more design alternatives than is possible today in an attempt to optimize several product characteristics, and quickly prototype complex products and processes. As part of RaDEO, the objective of the Manufacturing Simulation Driver (MSD) program was to develop, validate, and demonstrate the use of factory simulation to explore and compare alternative design approaches, alternative workflows, outsourcing of specific operations, and alternative internal and external factory utilization.

**Status**

*Complete*

*Start date: April 1996*

*End date: June 1998*

**Resources**

*Project Engineer:*

*John Barnes*

*AFRL/MLMS*

*(937) 255-7371*

*DARPA Funded*

*Contractor:*

*Raytheon Company*

## Completed Projects

### Minnesota Consortium for Defense Conversion

(Page 107) Cooperative Agreement Number: F33615-94-2-4417 ALOG Number: 1220

**Technical Report Number: In Progress**

The major objectives of this consortium were to: support the ability of Minnesota's defense suppliers to develop new commercial and defense dual-use products and markets; explore the feasibility of an electronic network; and obtain the information and knowledge to maintain the manufacturing capacity of Minnesota defense companies.

**Status**

*Complete*

*Start date: March 1994*

*End date: March 1998*

**Resources**

*Project Engineer:*

*Cliff Stogdill*

*AFRL/MLMS*

*(937) 255-7371*

*DARPA Funded*

*Contractor:*

*Minnesota Technology*

*Incorporated*

### National Industrial Information Infrastructure Protocols

(Page 113) Cooperative Agreement Number: F33615-94-2-4447 ALOG Number: 1227

**Technical Report Number: In Progress**

The National Industrial Information Infrastructure Protocols (NIIP) Consortium is a team of organizations that will consolidate, rationalize, and integrate a set of standards upon which applications will be built and virtual enterprises will be formed. Jobs will be created in the computer industry and in the organizations which participate in virtual enterprises.

**Status**

*Complete*

*Start date: September 1994*

*End date: November 1998*

**Resources**

*Project Engineer:*

*Theodore Finnessy*

*AFRL/MLMS*

*(937) 255-4623*

*DARPA Funded*

*Contractor:*

*International Business*

*Machines Corporation*

### Process Web: Process-Enable Planning & Composition of an Agile Virtual Corporation

(Page 120) Contract Number: F33615-96-C-5604 ALOG Number: 1473

**Technical Report Number: AFRL-ML-WP-TR-1998-4087**

This program developed and demonstrated an open, scalable modeling and simulation-based methodology and software for capturing virtual enterprise composing process models. The analysis methodology and software: (1) simplify and accelerate the virtual enterprise formation process and (2) produce an integrated product development process model which will serve as a guide to virtual enterprise formation and operation in the real world.

**Status**

*Complete*

*Start date: December 1995*

*End date: April 1998*

**Resources**

*Project Engineer:*

*Cliff Stogdill*

*AFRL/MLMS*

*(937) 255-7371*

*DARPA Funded*

*Contractor:*

*Intelligent Systems*

*Technology Incorporated*

# Completed Projects

## Reasoning in 3-Dimensions: A Common Framework for Design, Manufacturing and Tactical Planning

(Page 121) Contract Number: F33615-95-C-5560 ALOG Number: 1382

Technical Report Number: In Progress

A range of new tools and methods was required to reduce designer's risk in the realization of yet unproved design alternatives. The designer's imagination of complex geometric interactions (3D reasoning ) is frequently the bottleneck in the evaluation of feasible design solutions. This project developed tools to: automatically generate process plans to manufacture parts with the help of layered manufacturing (LM) techniques; provide a 'clean interface' between CAD and CAM through spatial decomposition of CAD models; and to facilitate manufacturability evaluation of complex CAD geometries.

<b>Status</b>	<b>Resources</b>	
<i>Complete</i>	<i>Project Engineer:</i>	<i>DARPA Funded</i>
<i>Start date: September 1995</i>	<i>Jon Jeffries</i>	<i>Contractor:</i>
<i>End date: September 1998</i>	<i>AFRL/MLMS</i>	<i>Stanford University</i>
	<i>(937) 255-7371</i>	

## System Designer Advisor Baseline Enhancement

(Page 129) Cooperative Agreement Number: F33615-96-2-5612 ALOG Number: 1482

Technical Report Number: In Progress

This project attempted to develop and demonstrate a capability to: address an order of magnitude more design alternatives relevant to development of electromechanical assemblies without extending design time; optimize design for several objectives such as quality, performance, cost, manufacturability, maintainability and reliability at the same time; and reduce prototype development cycle time. The tools and methodology reduced missile seeker design time, reduced prototype cost, and reduced the possibility that a new missile seeker design will place a missile program at significant risk.

<b>Status</b>	<b>Resources</b>	
<i>Complete</i>	<i>Project Engineer:</i>	<i>DARPA Funded</i>
<i>Start date: June 1996</i>	<i>Daniel Lewallen</i>	<i>Contractor:</i>
<i>End date: August 1998</i>	<i>AFRL/MLMS</i>	<i>Texas Instruments</i>
	<i>(937) 255-4623</i>	<i>Incorporated</i>

## Thoroughly Testing Known Good Die

(Page 131) Contract Number: F33615-94-C-4401 ALOG Number: 1186

Technical Report Number: AFRL-ML-WP-TR-1998-4401

The objective of this project is to develop, evaluate, and make available technologies for delivering known-good die. Macrocells have been developed to perform at speed testing of die at the wafer and assembled MCM occurrences of die. Demonstrations were given with die manufacturers using macrocells manufactured with the 0.25 micron process at National Semiconductor.

<b>Status</b>	<b>Resources</b>	
<i>Complete</i>	<i>Project Engineer:</i>	<i>DARPA Funded</i>
<i>Start date: December 1993</i>	<i>Bill Russell</i>	<i>Contractor:</i>
<i>End date: February 1998</i>	<i>AFRL/MLMS</i>	<i>Tektronix Inc.</i>
	<i>(937) 255-7371</i>	

# Completed Projects

## Virtual Test

(Page 132) Contract Number: F33615-93-C-4308 ALOG Number: 221

**Technical Report Number: In Progress**

The objective of this program was to develop and demonstrate the methodologies and tools necessary for the capture of tester-independent test requirements for complex electronics systems and the targeting of this information to test programs for multiple testers. This program used a test requirements specification language and developed tools for accepting this formatted information for the creation of test programs for multiple target testers.

### Status

*Complete*

*Start date: September 1993*

*End date: May 1998*

### Resources

*Project Engineer:*

*Daniel Lewallen*

*AFRL/MLMS*

*(937) 255-4623*

*Air Force Funded*

*Contractor:*

*Lockheed Martin*

*Federal Systems*

## Active Projects

## Behavior Analog Fault Simulation

(Page 73) Grant Number: F33615-96-1-5603 ALOG Number: 1422

**Update** - Analog and mixed signal testing follows different test methodologies from digital testing and is a bottleneck that not only leads to high testing costs, but also causes significant 'time-to-market' delays. The objective of this project was to develop methodology algorithms and prototype tools for performing behavioral analog fault simulations. This program developed a new design methodology that cuts both cost and time spent on mixed signal testing, with the goal of providing more automated test generation during the design phase which will integrate analog and digital testing.

### Status

*Active*

*Start date: December 1995*

*End date: February 1999*

### Resources

*Project Engineer:*

*Bill Russell*

*AFRL/MLMS*

*(937) 255-7371*

*DARPA Funded*

*Contractor:*

*University of Iowa*

## Built-In Test of Known Good Die

(Page 75) Grant Number: F33615-96-1-5610 ALOG Number: 1423

**Update** - The objective was to develop methodology algorithms and prototype tools for performing behavioral analog fault simulations. This project researched and developed tools and methodologies for the automation of test pattern generation for mixed signal modules. The project also researched tools and methodologies to determine stuck and delay faults for circuits as a part of known good die development.

### Status

*Active*

*Start date: February 1996*

*End date: April 1999*

### Resources

*Project Engineer:*

*Bill Russell*

*AFRL/MLMS*

*(937) 255-7371*

*DARPA Funded*

*Contractor:*

*Rutgers State University*

## Active Projects

### Collaborative Optimization Environment

(Page 76) Contract Number F33615-96-C-5613 ALOG Number 1483

**Update** - Under the Rapid Design Exploration Optimization (RaDEO) program, the General Electric Research and Development Center/Engineous Software team proposed to develop a unique Collaborative Optimization Environment (COE) software platform, which provided a key missing technology for developing affordable products with optimum performance through the systematic application of optimization to the IPPD process. The COE kernel along with its design automation, integration, and optimization utilities, offers a seamless development environment necessary for engineers to model, analyze, and optimize complex products and processes.

#### Status

*Active*

*Start Date: May 1996*

*End Date: May 1999*

#### Resources

*Project Engineer:*

*Brian Stucke*

*AFRL/MLMS*

*(937) 255-7371*

*DARPA Funded*

*Contractor:*

*Engineous Software, Inc.*

### Continuous Electronics Enhancements using Simulatable Specifications

(Page 81) Contract Number: F33615-93-C-4304 ALOG Number: 220

**Update** - The CEENSS program provided the capability for vendor independent descriptions and designs of electronics products. In so doing, it increases the line replaceable module (LRM) design initial verification and manufacturing success rate and also reduces the development time of electronic systems. It is providing re-design for the F-22 non-directional finder board located within the communication navigation and identification (CNI) avionics suite.

#### Status

*Active*

*Start date: September 1993*

*End date: January 1999*

#### Resources

*Project Engineer:*

*Alan Winn*

*AFRL/MLMS*

*(937) 255-4623*

*Air Force Funded*

*Contractor:*

*TRW Incorporated*

### Create a Process Analysis Toolkit for Affordability (PATA) Supporting the R&D Process

(Page 82) Contract Number: F33615-97-C-5141 ALOG Number: 1569

**Update** - The Process Analysis Toolkit for Affordability (PATA) is a two year development and commercialization project, intended to be used by the Air Force Science and Technology (S&T) community, including industry, academe, and government, to ensure that research and development projects have viable, usable and affordable results. This effort will produce stand alone and web-based inexpensive and easy to use toolkit capabilities rich in functionality. It's inexpensive because it takes advantage of the rapidly growing Internet infrastructure. Its unique browser technology and related standards make it convenient and easy to use. It supports a wide variety of activities, from on-line shopping (transaction management) to information retrieval, application sharing and collaborative design.

#### Status

*Active*

*Start date: September 1997*

*End date: September 1999*

#### Resources

*Project Engineer:*

*David Judson*

*AFRL/MLMS*

*(937) 255-7371*

*SBIR Funded*

*Contractor:*

*James Gregory Associates, Inc.*

## Electric Component Commerce

(Page 87) Cooperative Agreement Number: F33615-96-2-5116 ALOG Number: 1553

**Update** - Digital Market built an on-line marketplace (digital.market) for electronic components that connects engineering and procurement organizations directly to their preferred distributors to exchange information and transactions in real time. A buyer or engineer can upload a Bill of Materials (BOM) and forecast information directly into digital.market and quote and order components in real time from multiple distributors. This accelerates the process and lets high volume ESMs cost effectively procure material for low volume DoD manufacturing projects where manufacturing times are dominated by component procurement, prototype fabrication cycles, producibility analysis, and production setup times. The system has demonstrated a reduction in the overall cost of acquiring and managing materials, faster and more accurate information sharing in the supply chain, greater ability to respond to changes in engineering content and demand schedules, and immediate access for small quantity purchases.

### Status

*Active*

*Start date: October 1996*

*End date: December 1998*

### Resources

*Project Engineer:*

*Bill Russell*

*AFRL/MLMS*

*(937) 255-7371*

*DARPA Funded*

*Contractor:*

*Digital Market*

## Electronic Component Information Exchange

(Page 88) Cooperative Agreement Number: F33615-97-2-5121 ALOG Number: 1527

**Update** - The objective of this project is to provide an overall architecture and set of standards which support the flow of reusable electronic component information from its source to the user. The project is being implemented as an industry partnership under Silicon Integration Initiative (SI2) bylaws. It is led and managed by SI2 staff in partnership with sponsoring industry partners. The payoff will be a professionally documented architecture for a standards-based system supporting electronic commerce of electronic components, and a formally balloted (through SI2 membership) set of standards which support that architecture.

### Status

*Active*

*Start date: December 1996*

*End date: December 1998*

### Resources

*Project Engineer:*

*Bill Russell*

*AFRL/MLMS*

*(937) 255-7371*

*DARPA Funded*

*Contractor:*

*Silicon Integration*

*Initiative*

## Electronics CAD-CAM Exchange

(Page 89) Contract Number: F33615-96-C-5118 ALOG Number: 1524

**Update** - ECCE is a Defense Advanced Research Projects Agency (DARPA) funded program which will develop and demonstrate an integrated solution to providing compatibility between Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM). The goal of the ECCE program is to design a format for carrying CAM information (CAM-F) in a way that ensures a viable, sustainable method of CAD/CAM and CAM/CAM information transfer. ECCE will also demonstrate how the CAM information model can be populated with CAD data, enabling error-free transfer of data from CAD to CAM.

### Status

*Active*

*Start date: December 1996*

*End date: January 1999*

### Resources

*Project Engineer:*

*Bill Russell*

*AFRL/MLMS*

*(937) 255-7371*

*DARPA Funded*

*Contractor:*

*Intermetrics Inc.*

## Active Projects

### Flexible Environment for Conceptual Design

(Page 93) Contract Number: F33615-96-C-5617 ALOG Number: 1484

**Update** - The objective is to develop and demonstrate an integrated set of flexible engineering analysis and design tools for supporting conceptual design of complex engineering systems. This project seeks to build a computer environment which can tightly integrate analysis across multiple disciplines. It will have the flexibility to let the analyst quickly explore new opportunities as they arise by making it as simple as possible to extend and/or modify analysis models.

#### Status

*Active*

*Start date: June 1996*

*End date: April 1999*

#### Resources

*Project Engineer:*

*Daniel Lewallen*

*AFRL/MLMS*

*(937) 255-4623*

*DARPA Funded*

*Contractor:*

*Rockwell International*

*Corporation*

### Integrated Knowledge Environment - Integrated Product Management

(Page 96) Contract Number: F33615-96-C-5109 ALOG Number: 1462

**Update** - The Integrated Knowledge Environment-Integrated Program Management (IKE-IPM) framework and application is now in its six release. IKE is now a full up object development and object processing, management system. The IPM application has been re-engineered to run in the object CZAR on top of the common object broker standards CORBA and a real time communications network. This has been the basis of the virtual enterprise development involving 100 small businesses. This framework is being piloted for managing on acquisition and sustainment projects assessing cost of processes, their schedules, performance and risk in product development and maintenance.

#### Status

*Active*

*Start date: May 1996*

*End date: August 1999*

#### Resources

*Project Engineer:*

*David Judson*

*AFRL/MLMS*

*(937) 255-7371*

*SBIR Funded*

*Contractor:*

*Knowledge Base Engineering*

*Inc.*

### Internal Real-Time Distributed Object Management System

(Page 99) Contract Number: F33615-96-C-5112 ALOG Number: 1442

**Update** - The objective of this project was to establish a real-time communications service internal to Common Object Request Broker Architecture (CORBA) services, supporting the application user and external user sites. This Internal Real-Time Distributed Object Management System (IR-DOMS) has resolved heterogeneous platform issues and provides the end user with a seamless reliable capability to perform their jobs. The approach developed a commercial prototype software product called ORB\_IT (Object Request Broker - Integration Technology), that operates on fiberchannel standards supporting many protocols to facilitate "seamless" and "transparent" technical and business computing homogeneously in a networked environment.

#### Status

*Active*

*Start date: March 1996*

*End date: December 1998*

#### Resources

*Project Engineer:*

*David Judson*

*AFRL/MLMS*

*(937) 255-7371*

*SBIR Funded*

*Contractor:*

*Systran Corporation*

## Joint Strike Fighter Technology Manufacturing Demonstrations

(Page 100) Contract Number: F33615-95-C-5529 ALOG Number: 1359

**Update** - This program will develop and demonstrate improved cost/design methodologies which can be applied to the Joint Strike Fighter (JSF) during engineering and manufacturing development (EMD) to reduce life-cycle cost. The JSF Manufacturing Demonstration is developing procedures, business practices, processes and infrastructure improvements necessary to conduct product and process design using integrated cost and design data. The integrated methodologies and data will enable designers to quickly and accurately conduct design/cost trades, manufacturing process selection and cost estimation.

### Status

*Active*

*Start date: April 1995*

*End date: December 1998*

### Resources

*Project Engineer:*

*Al Herner*

*AFRL/MLMS*

*(937) 255-9245*

*JSF Funded*

*Contractor:*

*Hughes Aircraft Company*

## MEREOS - A Product Definition Management System

(Page 106) Contract Number: F33615-95-C-5519 ALOG Number: 1370

**Update** - The objective of the MEREOS project is to develop a product definition management system based on PACIS®, a next-generation ANSI/ISO database management system. The goal of the system is to solve the multiple bill of materials reconciliation problem in large-scale, complex product manufacturing environments. The specific objective is to provide end users with the ability to define, modify, query, and automatically maintain relationships between several distinct BOMs, specification trees, and functional structures for a single product, where the information involved is stored in databases.

### Status

*Active*

*Start date: December 1994*

*End date: December 1999*

### Resources

*Project Engineer:*

*Wallace Patterson*

*AFRL/MLMS*

*(937) 255-4623*

*Air Force Funded*

*Contractor:*

*Ontek Corporation*

## Missile Industry Supply Chain Technology Initiative (MISTI)

(Page 108) Contract Number: F33615-96-C-5115 ALOG Number: 1522

**Update** - The objective of the MISTI program is to define, develop, implement, demonstrate, and quantify the benefits of a set of innovative, high-impacting tools and technologies which utilize the Internet to create an agile integrated missile supply chain. Technologies, services, and applications resulting from work will be integrated and deployed into a series of metricized alpha tests to demonstrate their widespread applicability and impact for efficient supply chain integration in support of the AM3 goals of significant missile sector acquisition cost reduction, time compression, and quality improvement.

### Status

*Active*

*Start date: November 1996*

*End date: March 1999*

### Resources

*Project Engineer:*

*Jon Jeffries*

*AFRL/MLMS*

*(937) 255-7371*

*DARPA Funded*

*Contractor:*

*Science Applications*

*International Corp*

## Active Projects

### Mixed Signal Test (MiST)

(Page 109) Cooperative Agreement Number: F33615-95-2-5562 ALOG Number: 1346

**Update** - The objective is to develop a set of integrated design and test tools for the development of mixed signal multi-chip modules and printed circuit boards. In this program, the contractor proposes to expand the capability of the IMS MCM Test Development System (TDS) to incorporate specification testing in the design hierarchy and relate it to the underlying analog fault models. Mixed-signal scan and multiplexing techniques will be introduced into the design-for-test process to enhance accessibility. The development and demonstration of control and observation test structures for analog devices will also be accomplished.

#### Status

*Active*

*Start date: September 1995*

*End date: December 1998*

#### Resources

*Project Engineer:*

*Bill Russell*

*AFRL/MLMS*

*(937) 255-7371*

*DARPA Funded*

*Contractor:*

*Boeing Company*

### Multiphase Integrated Engineering Design (MIND)

(Page 112) Contract Number: F33615-96-C-5621 ALOG Number: 1479

**Update** - As part of the Rapid Design Exploration Optimization (RaDEO), the objective of this project is to provide for the development of key enabling technologies and tools to support integrated products from early stage design through manufacture for electromechanical parts.

#### Status

*Active*

*Start date: March 1996*

*End date: March 1999*

#### Resources

*Project Engineer:*

*Alan Winn*

*AFRL/MLMS*

*(937) 255-4623*

*DARPA Funded*

*Contractor:*

*University of Utah*

### Net Shape Casting Production Machine

(Page 114) Contract Number: F33615-97-C-5123 ALOG Number: 1546

**Update** - The objective of this project is to use the Advanced Pressure Infiltration Casting (APIC<sup>TM</sup>) process as a low cost method of manufacture for cast metal matrix composite components. PWB electronic boards and a liquid-cooled hollow brake rotor for flight-line tow tractors is the component which will be developed to demonstrate the technology during the first year. A bench scale water vaporization cooled aircraft brake rotor was used to demonstrate rapid redesign/reengineering features of the Net Shape Casting System, during the second year. MMCC has installed SDRC's Finite Element Analysis software to analyze stress and strains throughout a part, so part designs can be readjusted to best utilize a composite's properties and optimize these for minimum weight.

#### Status

*Active*

*Start date: April 1997*

*End date: July 1999*

#### Resources

*Project Engineer:*

*David Judson*

*AFRL/MLMS*

*(937) 255-7371*

*SBIR Funded*

*Contractor:*

*Metal Matrix Cast Components Consortium,*

### New England Supplier Institute

(Page 115) Cooperative Agreement Number: F33615-94-2-4424 ALOG Number: 1228

**Update** - The Corporation for Business, Work, and Learning is leading a six-state, industry-driven consortium, the New England Supplier Institute (NESI), in a pilot program which is identifying, coordinating and delivering technology deployment services to the region's supplier base.

#### Status

*Active*

*Start date: August 1994*

*End date: December 1998*

#### Resources

*Project Engineer:*

*Wallace Patterson*

*AFRL/MLMS*

*(937) 255-4623*

*DARPA Funded*

*Contractor:*

*Corporation for Business, Work, and Learning*

## Robust Design Computational System

(Page 123) Cooperative Agreement Number: F33615-96-2-5618 ALOG Number: 1477

**Update** - The objective of this effort is to develop and demonstrate engineering tools and information integration capabilities that could be used to evaluate more design alternatives than is possible today. The capability will be used to optimize several product characteristics such as reduction of performance variability, increased robustness and reliability.

### Status

*Active*

*Start date: June 1996*

*End date: October 1999*

### Resources

*Project Engineer:*

*Daniel Lewallen*

*AFRL/MLMS*

*(937) 255-4623*

*DARPA Funded*

*Contractor:*

*Rockwell International*

## Simulation Assessment Validation Environments

(Page 124) Contract Number: F33615-95-C-5538 ALOG Number: 1336

**Update** - The "Simulation Assessment Validation Environments" (SAVE) program is a first step in realizing the near-term objectives common to Virtual Manufacturing (VM) and the Joint Strike Fighter (JSF) program. The objective of SAVE is to implement, demonstrate, and validate integrated modeling and simulation tools and methods used to assess the impacts of product/process decisions on the affordability of advanced strike warfare technology. In August 1998, the SAVE program successfully demonstrated the latest version of the SAVE Data Model and Integration environment. This latest version of SAVE is based on a Common Object Request Broker Architecture (CORBA) approach and allows access to the data model while insulating the integrated tool suite from the specifics of data location and storage mechanisms. In addition, a flexible web-based data model editor/browser was demonstrated which allows design team members to view and update information within the SAVE data model directly. Capabilities which were integrated into the SAVE environment for this demonstration include: Component Design, Tool Design, Tolerance Analysis, Assembly Planning, Ergonomic Assessment, Factory Floor Simulation, Risk Assessment, and Cost Analysis. The SAVE Phase II interim demo was based on a current redesign of the F-22 gun port. The F-22 gun port and surrounding skin experienced erosion problems due to muzzle blast when the gun was test fired, necessitating a redesign. The design alternatives were analyzed within the SAVE environment. Manufacturing simulations were performed and cost, schedule and risk for each of the alternatives were assessed.

### Status

*Active*

*Start date: April 1995*

*End date: December 1999*

### Resources

*Project Engineer:*

*James Poindexter*

*AFRL/MLMS*

*(937) 255-7371*

*JSF Funded*

*Contractor:*

*Lockheed Martin*

*Aeronautical Systems Corporation*

# Weapon System-Integrated Cost Model (WS-ICM) Cost Estimate Model

**Contract Number:** Numerous

**ALOG Number:** 1670-1673

## Statement of Need

The Air Force Manufacturing Technology Division, in conjunction with the F-22 System Program Office (SPO), is interested in the establishment of a methodology that supports weapon systems production management considering cost as an independent variable throughout the total life cycle. The core of this methodology must be generic weapon systems based cost models, tailorable and flexible enough to be accessed by tools and techniques used by industry. The objective of this project is to develop a weapon systems cost methodology for predictive decision weapon system cost analysis and support.

## Approach

A Weapon System-Integrated Cost Model (WS-ICM) framework of integrated cost architectures will be developed for major cost categories of a weapon system by control level, within and among prime and subcontractors. The WS-ICM and its component cost architectures must be designed, constructed, populated, validated and demonstrated to cost experts and program managers from across industry and government. Extensive consideration must be given to building on standards-based approaches with compatible historical data interfaces enabling use (for example) of R&D, mods, spares, sustainment, prior best business practices, infrastructure, labor, learning curve data and realization cost factors, etc. Each of the contractors were awarded separate contracts to create a conceptual WS-ICM framework design during Phase I from which to launch detailed work on the contract's specific cost model target, tools and integration strategy (i.e., the life-cycle Cost Estimating Model (CEM) or the Operational and Support Model (OSM)). A Production Cost Model (PCM) is currently being developed for demonstration and will be shared for integration with the contractors. In the integrated WS-ICM demonstration, containing models produced by different organizations, the user must see a single and consistent view of the data, while being networked, using dissimilar computers, geographically separated, and operating in a secured (as required) repository mutually available for use by government and industry teams supporting WS-ICM and individual WS cost models. The F-22 SPO will participate in the technical evaluation and reviews in all phases of this project with anticipation of potential use of high quality successful automated results.

## Benefits

The contractor will develop a conceptual WS-ICM model and multiple levels of decomposition giving context to the CEM, PCM and OSM and lower level cost components supporting each contractor's demonstration and the WS-ICM demo. The WS-ICM has come from a strong customer pull (SPOs and contractors) that has need of tools to help them make accurate affordability decisions early on in concept exploration activities of the new acquisition environment. The market is large scale weapon systems development programs.

## Status

*Active*

*Start date: May 1998*

*End date: May 2001*

## Resources

*Project Engineer:*

*David Judson*

*AFRL/MLMS*

*(937) 255-7371*

*SBIR Funded*

*Contractor:*

*Numerous*

*JDMTP Subpanel:*

*Advanced Manufacturing*

*Enterprise*

## Advanced Six-Degree-of-Freedom Laser Measurement System

(Page 134) Contract Number: F33615-96-C-5106 ALOG Number: 1449

Technical Report Number: In Progress

This Phase II Small Business Innovation Research (SBIR) program continued the Phase I technical effort. The contractor will designed, built, and demonstrated a prototype six-degree-of-freedom laser measurement system. The system is intended to measure geometric errors in the X, Y, and Z axis and pitch, yaw, and roll rotations of machine tools and coordinate measuring machines (CMM).

### Status

*Complete*

*Start date: July 1996*

*End date: July 1998*

### Resources

*Project Engineer:*

*Rafael Reed*

*AFRL/MLMP*

*(937) 255-2413*

*SBIR Funded*

*Contractor:*

*Automated Precision Inc.*

## Flexible Fabrication with Superconducting Magnetic Clamps

(Page 138) Cooperative Agreement Number: F33615-95-2-5540 ALOG Number: 1379

Technical Report Number: AFRL-ML-WP-TR-1998-4070

This project developed and promoted the commercialization of new flexible tooling systems that extend the state-of-the-art of current tooling capabilities, and through their use, significantly reduce non-recurring tooling costs. The program designed, built, and demonstrated a flexible manufacturing tooling system for composite and metal fabrication and trim.

### Status

*Complete*

*Start date: August 1995*

*End date: December 1997*

### Resources

*Project Engineer:*

*Kevin Spitzer*

*AFRL/MLMP*

*(937) 255-2413*

*DARPA Funded*

*Contractor:*

*Boeing Company*

## Flexible Laser Automated Intelligent Research System for Manufacturing and Fabrication

(Page 139) Contract Number: F33615-95-C-5503 ALOG Number: 1354

Technical Report Number: In Progress

The Flexible Laser Automated Intelligent Research (FLAIR) System for Manufacturing and Fabrication brought together several advanced technologies by providing the research and development to demonstrate advanced laser processing of materials. The program developed laser-material interaction modeling for titanium and lead alloys to support industrial applications. Various laser processing methods were explored for joining, forming, and surface treatment of titanium fabricated materials and for the weldability of lead alloys. The knowledge from this program will be applied to two industrial processes. The first application will be the repair and surface treatment of titanium turbine blades. The second application will be for production welding of lead-acid battery components.

### Status

*Complete*

*Start date: April 1995*

*End date: June 1998*

### Resources

*Project Engineer:*

*Rafael Reed*

*AFRL/MLMP*

*(937) 255-2413*

*DARPA Funded*

*Contractor:*

*American Welding Society*

# Completed Projects

## Large Aircraft Robotic Paint Stripping

(Page 142) Contract Number: F33615-91-C-5708 ALOG Number: 165

Technical Report Number: In Progress

The prime objective of this program was to establish for Oklahoma City Air Logistics Center (OC-ALC) an automated, low-cost paint removal capability for large aircraft with minimal environmental impact. The program established an automated stripping process with the following characteristics: reduced aircraft preparation, cleanup, and depaint man-hours; reduced depot flow time; reduced ALC personnel exposure to the extremely hazardous work environment; lower cost; and a significant reduction of toxic/hazardous waste produced.

### Status

*Complete*

*Start date: June 1991*

*End date: August 1998*

### Resources

*Project Engineer:*

*David See*

*AFRL/MLMP*

*(937) 255-3612*

*Air Force Funded*

*Contractor:*

*United Technologies*

*Corporation*

## Laser Forming for Flexible Fabrication

(Page 143) Contract Number: F33615-95-C-5542 ALOG Number: 1369

Technical Report Number: In Progress

Reconfigurable tooling for metal forming, welding and surface treatment of composites, superalloys, refractory alloys, and titanium alloys for fabrication of propulsion and platform systems components is in high demand in today's industrial environment. The objectives of this program were to demonstrate the feasibility to predictably laser form components without the use of heavy machinery and tooling.

### Status

*Complete*

*Start date: September 1995*

*End date: August 1998*

### Resources

*Project Engineer:*

*Rafael Reed*

*AFRL/MLMP*

*(937) 255-2413*

*DARPA Funded*

*Contractor:*

*Rockwell International Corp*

## Metal Forming Simulation

(Page 146) Contract Number: F33615-93-C-5318 ALOG Number: 615

Technical Report Number: AFRL-ML-WP-TR-1998-4073

This program established a computer-aided design/computer-aided manufacturing/computer-aided engineering (CAD/CAM/CAE) system to simulate the Guerin sheet metal forming process. The simulated forming process was then used to test CAD models of various dies, for part formability. The overall objective was the reduction of tool concept to part production time, increased part quality through improved tool design, and an overall cost per part reduction. Variations of the Guerin process including hydroform, hydropress, and fluid cell (also known as the Verson-Wheelon) were also simulated.

### Status

*Complete*

*Start date: July 1993*

*End date: March 1998*

### Resources

*Project Engineer:*

*Deborah Kennedy*

*AFRL/MLMP*

*(937) 255-3612*

*Air Force Funded*

*Contractor:*

*Northrop Grumman*

## Metal Forming Tool Design

(Page 147) Contract Number: F33615-96-C-5107 ALOG Number: 1460

Technical Report Number: In Progress

This Small Business Innovation Research (SBIR) Phase II project was sponsored by the Director Defense Research & Engineering to transfer DoD developed technology into the private sector. The project transferred technology from the Advanced Tooling Manufacture for Composite Structures (ATMCS) program into the metal forming domain. The objective was to design and implement an intuitive, easy to use, expandable, full function, brake forming, stretch forming, and hydroforming tool design software based on the original Manufacturing Technology Division ATMCS technology.

### Status

*Complete*

*Start date: June 1996*

*End date: June 1998*

### Resources

*Project Engineer:*

*Marvin Gale*

*AFRL/MLMP*

*(937) 255-7278*

*SBIR Funded*

*Contractor:*

*FEM Engineering*

## Moisture Detection in Honeycombs via Advanced Radioscopy

(Page 149) Contract Number: F33615-91-C-5623 ALOG Number: 1525

Technical Report Number: In Progress

The goal of this program was to develop and transition a portable high resolution real-time X-ray radiographic (HRRTR) imaging system capable of assessing physical and chemical properties of complex multi-phase materials. The program consisted of the design, construction, evaluation, and demonstration of a prototype advanced real-time radiographic imaging capability based on the development of a solid state X-ray detector.

### Status

*Complete*

*Start date: November 1996*

*End date: October 1998*

### Resources

*Project Engineer:*

*Deborah Kennedy*

*AFRL/MLMP*

*(937) 255-3612*

*Air Force Funded*

*Contractor:*

*Lockheed Martin*

*Missiles & Space*

## Neural Network Error Compensation of Machine Tools

(Page 150) Contract Number: F33615-95-C-5541 ALOG Number: 1389

Technical Report Number: AFRL-ML-WP-TR-1998-4077

The purpose of this Phase II Small Business Innovation Research project was to develop a robust and cost-effective method to compensate for geometric and thermal errors in machine tools. It makes use of the self-learning properties of artificial neural networks (ANN) to predict the net positioning error at an arbitrary point in the workspace from knowledge of the error at some specified points in the workspace. This knowledge is obtained from the measurement of geometric errors and their thermal variations as well as correlation with other process variables.

### Status

*Complete*

*Start date: August 1995*

*End date: January 1998*

### Resources

*Project Engineer:*

*Siamack Mazdiasni*

*AFRL/MLMP*

*(937) 255-2413*

*SBIR Funded*

*Contractor:*

*Tetra Precision Inc.*

# Completed Projects

## Precision Machining Program

(Page 152) Contract Number: F33615-94-C-4440 ALOG Number: 1271

Technical Report Number: In Progress

The objective of the Precision Machining Program was to investigate widely used machining operations, namely turning, boring, milling and grinding, and to design, fabricate and demonstrate integrated systems for reducing dynamic machine tool errors. The ultimate goal was to develop modular system components that can be installed as retrofits on large classes of machines for suppression of vibrations at the cutting tool-to-workpiece interface.

### Status

*Complete*

*Start date: July 1994*

*End date: January 1998*

### Resources

*Project Engineer:*

*Laura Leising*

*AFRL/MLMP*

*(937) 255-3612*

*DARPA Funded*

*Contractor:*

*General Dynamics*

*Advanced Technology Systems*

## Production Laser Peening Facility Development

(Page 153) Contract Number: F33615-96-C-5624 ALOG Number: 1456

Technical Report Number: In Progress

The objective of this Phase II Small Business Innovation Research (SBIR) project was to extend the Phase I research to develop a state-of-the-art laser peening facility. It is capable of meeting the near term production needs of the Air Force while providing a facility for the introduction of laser shock peening to other commercial markets. This effort demonstrated the operation of an industrial grade, Class 1 laser system for laser shock processing and integrated it to an enclosed robotic work station to form a complete laser shock processing facility.

### Status

*Complete*

*Start date: April 1996*

*End date: December 1997*

### Resources

*Project Engineer:*

*David See*

*AFRL/MLMP*

*(937) 255-3612*

*SBIR Funded*

*Contractor:*

*LSP Technologies, Inc.*

## Ultra-Thin Cast Nickel-Base Alloy Structures

(Page 156) Contract Number: F33615-93-C-4305 ALOG Number: 710

Technical Report Number: In Progress

This program applied advanced materials processing technology to the manufacture of propulsion and structural components. The program began with the casting process development/selection, process demonstration, and then hardware fabrication/qualification. The goal of this program was to develop cost-effective manufacturing processes capable of producing ultra-thin (10-20 mm) single-crystal cast components.

### Status

*Complete*

*Start date: September 1993*

*End date: September 1998*

### Resources

*Project Engineer:*

*Rafael Reed*

*AFRL/MLMP*

*(937) 255-2413*

*Air Force Funded*

*Contractor:*

*United Technologies*

*Corporation*

## Advanced Reconfigurable Machine for Flexible Fabrication

(Page 133) Contract Number: F33615-95-C-5500 ALOG Number: 1352

**Update** - This effort: 1) developed a reconfigurable machine for flexible fabrication of critical military components; 2) demonstrated high throughput, high precision, low cost production of aerospace components; 3) transitioned technology to spacecraft and robotic vibration control and precision position; and 4) introduced advanced materials technology into the U.S. machine tool industry.

### Status

*Active*

*Start date: April 1995*

*End date: July 1999*

### Resources

*Project Engineer:*

*Deborah Kennedy*

*AFRL/MLMP*

*(937) 255-3612*

*DARPA Funded*

*Contractor:*

*Lockheed Martin Corp.*

## Engine Supplier Base Initiative

(Page 137) Cooperative Agreement Number: F33615-95-2-5555 ALOG Number: 1265

**Update** - A need exists to establish a national initiative to address the affordability of gas turbine engines by attacking the high cost areas known to exist. This program is aimed at providing more affordable propulsion by identifying and attacking high cost manufacturing processes and business practices within the military engine supplier base community.

### Status

*Active*

*Start date: September 1995*

*End date: August 2001*

### Resources

*Project Engineer:*

*Siamack Mazdinyani*

*AFRL/MLMP*

*(937) 255-2413*

*Air Force Funded*

*Contractor:*

*Howmet Corporation*

## Lean Blade Repair Pilot

(Page 144) Contract Number: F33615-93-C-4301 ALOG Number: 314

This program established advanced manufacturing technology for cost-effective semi-to-automatic repair processes for selected Air Force high performance gas-turbine engine components. These technologies will be installed at Oklahoma City Air Logistics Center (OC-ALC). This effort involved selecting the most efficient and cost-effective process between laser and pulsed-arc welding technologies. These two processes have proven to provide excellent weld properties on a laboratory scale, but have not been used in production.

### Status

*Active*

*Start date: September 1993*

*End date: March 2000*

### Resources

*Project Engineer:*

*Rafael Reed*

*AFRL/MLMP*

*(937) 255-2413*

*Air Force Funded*

*Contractor:*

*General Atomics Corporation*

# Active Projects

## Mobile Automated Scanner (MAUS)

(Page 148) Contract Number: F33615-91-C-5664 ALOG Number: 1508

**Update** - This program extended the work previously completed under the Large Area Composite Inspection System (LACIS) program to enhance the Mobile Automated Scanner (MAUS III) nondestructive testing system with additional bond testing capabilities. Specific enhancements considered were pitch-catch resonance, mechanical impedance analysis, eddysonic and automated tap testing. Additional program goals included improved operator ergonomics, enhanced system durability, and reduced inspection costs.

### Status

*Active*

*Start date: November 1996*

*End date: December 1998*

### Resources

*Project Engineer:*

*Deborah Kennedy*

*AFRL/MLMP*

*(937) 255-3612*

*Air Force Funded*

*Contractor:*

*Boeing Company*

## Precision High Speed Machining With Vibration Control

(Page 151) Contract Number: SPO900-94-C-0010 ALOG Number: 1261

**Update** - There are three main obstacles that limit the metal removal rates of high speed machines for production of complex, flexible aerospace structures with superior quality: 1) Vibration, leading to damaged part surfaces; 2) Low feed rates and accelerations leading to excessive slow down and time spent in cornering; and 3) Limited path accuracy at higher feed rates resulting in overshoot conditions. The objective of this program was to design, develop, and demonstrate a very agile and dynamically stable High Speed, High Feed Rate, 5-Axis Machine Tool for producing extremely flexible aluminum aerospace structures with superior quality, minimum weight, and reduced part cost.

### Status

*Active*

*Start date: May 1994*

*End date: September 1999*

### Resources

*Project Engineer:*

*Rafael Reed*

*AFRL/MLMP*

*(937) 255-2413*

*DARPA Funded*

*Contractor:*

*McDonnell Douglas Corp.*

## Titanium Matrix Composite Turbine Engine Component Consortium (TMCTECC)

(Page 155) Cooperative Agreement Number: F33615-94-2-4439 ALOG Number: 1286

**Update** - Modern aircraft performance is directly related to "thrust to weight" ratio of engines and the combined weight of the aircraft structure, systems, subsystems, and fuel. Titanium Matrix Composites can provide engine manufacturers and aircraft companies the capability of significantly reducing weight while providing increased performance. Unfortunately these materials are very expensive and the production base does not exist to affordably and routinely produce affordable, high quality components. The aim of this cost-shared program is to mature the TMC fabrication industry and deploy TMC's in advanced gas turbine engines.

### Status

*Active*

*Start date: August 1994*

*End date: August 1999*

### Resources

*Project Engineer:*

*Kevin Spitzer*

*AFRL/MLMP*

*(937) 255-2413*

*Air Force Funded*

*Contractor:*

*Titanium Matrix Composite  
Turbine Engine Component  
Consortium*

# Detection of Hidden Substructure Edges and Holes

Contract Number: F33615-98-C-5102

ALOG Number: 1595

Technical Report Number: AFRL-ML-WP-TR-1998-4069

## Statement of Need

The assembly of aircraft structure involves precision alignment of skins to substructure (bulkheads, frames, spars/ribs, etc.) prior to the drilling and filling of fastener holes. All hole locations and edge distances are constrained to tight tolerances to achieve the lightest structural weight, highest structural integrity, and the lowest radar signature. Closely matched holes that fit snugly to the fasteners at the minimum allowable distance from the panel's and substructure's edge are desired. The current methods for locating holes and edges requires the assembly technician to use hard templates or to view the assembly from the underside to mark the outer skin with edge and hole location markings. Often excess material and edge distances are required to compensate for alignment inaccuracies. Low cost innovative equipment and techniques are needed that provide the assembly technician with accurate and timely information on the edge and hole locations of hidden substructure relative to mating outer skins. This information should include a visual display or markings to assist the aircraft assembly technician in drilling properly aligned holes and verifying edge distance requirements.

## Approach

Pacific-Sierra Research Corp. (PSR) developed a robotic-thermographic system capable of revealing the presence of hidden edges and holes in aircraft structures and marking their exact location. PSR produced a robotic-thermographic workstation with enough thermal sensitivity, spatial resolution, and precision alignment, allowing the accurate quantitative determination of where to machine properly aligned holes and verify edge distance requirements. Phase I provided the data base that will be a source for a Phase II hardware fabrication system design endeavor which will result in a portable robotic-thermographic system prototype.

## Benefits

The ability to sense and display hidden structure would have a profound impact on both commercial and military markets. Significant cost reductions could be realized in assembly operations, which is the largest single cost area associated with the manufacture of commercial and military aircraft.

## Status

*Complete*

*Start date: October 1997*

*End date: April 1998*

## Resources

*Project Engineer:*

*Vincent Johnson*

*AFRL/MLMP*

*(937) 255-7277*

*SBIR Funded*

*Contractor:*

*Pacific-Sierra*

*Research Corporation*

*JDMTP Subpanel:*

*Composites*

# Hand Held High Resolution Imaging Device for Aircraft

Contract Number: F33615-97-C-5158

ALOG Number: 1594

Technical Report Number: AFRL-ML-WP-TR-1998-4081

## Statement of Need

The assembly of aircraft structure involves precision alignment of skins to substructure (bulkheads, frames, spars/ribs, etc.) prior to the drilling and filling of fastener holes. All hole locations and edge distances are constrained to tight tolerances to achieve the lightest structural weight, highest structural integrity, and the lowest radar signature. Closely matched holes that fit snugly to the fasteners at the minimum allowable distance from the panel's and substructure's edge are desired. The current methods for locating holes and edges requires the assembly technician to use hard templates or to view the assembly from the underside to mark the outer skin with edge and hole location markings. Often excess material and edge distances are required to compensate for alignment inaccuracies. Low cost innovative equipment and techniques are needed that provide the assembly technician with accurate and timely information on the edge and hole locations of hidden substructure relative to mating outer skins. This information should include a visual display or markings to assist the aircraft assembly technician in drilling properly aligned holes and verifying edge distance requirements. The goal of this Phase I SBIR program was to develop an easy-to-use probe for imaging aircraft substructures. The system will consist of a very compact (camera-sized) probe linked to a processor display. The final configuration of this processor display may be a notebook computer or an smaller device similar to a hand-held TV.

## Approach

Eikos LLC evaluated two approaches: millimeter waves and optical acoustics, for locating edges and holes in substructure that is hidden under exterior panels and skins during aircraft assembly. Eikos has developed approaches to both techniques that have the potential to be low cost and easy-to-use tools during aircraft assembly. Both approaches will yield hand-held, high resolution imaging devices based on inexpensive, commercially available components. Both systems are based on laser and nonlinear optical configurations.

## Benefits

The ability to sense and display hidden structure would have a profound impact on both commercial and military markets. Significant cost reductions could be realized in assembly operations, which is the largest single cost area associated with the manufacture of commercial and military aircraft.

## Status

*Complete*

*Start date: October 1997*

*End date: November 1998*

## Resources

*Project Engineer:*

*Vincent Johnson*

*AFRL/MLMP*

*(937) 255-7277*

*SBIR Funded*

*Contractor:*

*Eikos LLC*

*JDMTP Subpanel:*

*Composites*

# Identification and Quantification of Structural Damage (Structural Repair of Aging Aircraft)

Cooperative Agreement Number: F33615-97-2-5151

ALOG Number: 1544

## Statement of Need

The objective of this program is to develop, validate and deliver an automated, eddy current inspection system that will give the Air Force an invaluable damage detection tool to help effectively maintain its aging aircraft fleet. The final deliverable will be a portable, field-ready inspection tool that will rapidly detect small cracks and corrosion in complex aircraft structures. This tool will also have a direct and broad application within the aging commercial aircraft industry. Both economic and safety improvements will be realized within both the commercial and military aircraft fleets. A major requirement for activities undertaken as part of this program is to define multiple demonstration/application candidates for any technical effort. A minimum of two Air Force target applications are required for each project. The initial target set are KC-135, C-141, B-1B, F-16 and T-38 systems. It is expected that the demonstration SPDs will define metrics/gates and fund activities required to implement the results if success is achieved. The second application candidate is required to spur technology transfusion.

## Approach

The approach includes the "As-Bid" activities from Northrop Grumman Corporation, which is coupled to the efforts of an Air Force Integrated Product Team (IPT) composed of participants from Air Force Research Laboratory, the Air Logistic Centers (ALCs), Technology Directorates, and System Program Directors (SPDs). The team is focused on obtaining user participation and buy-in at both the SPD and maintenance levels to assure that if success measures are achieved, the commitment will be obtained in advance to provide implementation resources.

## Benefits

This project will develop an inspection tool which is potentially applicable to virtually every DoD aircraft. In terms of impact potential per government investment dollar, the project is viewed as outstanding. If the proposed effort is successful, the field of nondestructive inspections (NDI) between programmed depot maintenance inspections will be reduced or eliminated. The POI increase equates directly to an increase in aircraft availability — all of which are highly desired benefits and have corresponding reductions in cost. A significant commercial and military market is anticipated for the system due to the time and labor savings that can be realized with by its implementation.

## Status

*Active*

*Start date: October 1997*

*End date: April 1999*

## Resources

*Project Engineer:*

*Michael Waddell*

*AFRL/MLMP*

*(937) 255-7277*

*Air Force Funded*

*Contractor:*

*Northrop Grumman Corporation*

*JDMTP Subpanel:*

*Composites*

**Metals**

**Metals**

# Integrated Manufacturing and Quality Control Tools for Affordable Composite Product Realization

Contract Number: F33615-97-C-5146

ALOG Number: 1593

## Statement of Need

As the aerospace industry moves into the new millennium, the drive towards high performance materials and smart weapon systems is balanced by the economic necessity of building affordable weapon systems. Products manufactured from composite materials are of significant interest to the Air Force due to their unique properties. Presently, there is no comprehensive framework for estimating the life cycle costs for composite products and for evaluating manufacturability of these products. In order to design affordable, high quality products, designers must be able to predict the life cycle costs at an early stage, since over 70 percent of the life cycle costs are determined during the design phase. Life cycle cost or total product cost is composed of processing cost, quality cost, manufacturing system cost, supply chain cost, and environmental costs. Estimation of each of these costs presents a formidable challenge, especially if the product is still at the design stage.

## Approach

This program presents a collaborative effort between academia, a defense contractor, and a defense laboratory to develop a methodology for evaluating composite products and implement a prototype integrated manufacturing and quality control (IMQC) system for specific DoD weapon system programs at a prime defense contractor site.

## Benefits

The result of this research will integrated the statistical process control methods for low volume composite production and the composite manufacturability evaluation tools with Air Force weapons programs. The goal of this project is to create an integrated framework for the design and evaluation of advanced composite products based on functional needs, process capabilities, processing requirements, and environmental impact, all which are in the actual weapon system environment.

## Status

*Active*

*Start date: September 1997*

*End date: November 2000*

## Resources

*Project Engineer:*

*Vincent Johnson*

*AFRL/MLMP*

*(937) 255-7277*

*Air Force Funded*

*Contractor:*

*Florida A&M University*

*JDMTP Subpanel:*

*Composites*

# Lean Transition of Emerging Industrial Capability (LeanTEC)

Cooperative Agreement Number: F33615-97-2-5153

ALOG Number: 1679

## Statement of Need

The objective is to apply Lean practices and principles to identify new methods which enable timely and affordable insertion of advanced technology into weapon systems. This program targets those process improvements within a manufacturing enterprise that enhance the transfer of advanced technology from the development laboratory to manufacturing with attendant benefits in product performance and quality and with reduced cost and development-to-implementation cycle time.

## Approach

The approach is to: a) select candidate technologies to assess technology transition process; b) identify technology transition barriers and new methodologies/strategies for dealing with barriers; c) study suitable benchmarks; d) structure a model of the "As-Is" technology transition process; e) structure a model of the "To-Be" technology transition process; f) formulate experiments to validate improvements and benchmarks in the "To-Be" model; g) conduct experiments and quantify the results in terms of improved technology transition into Air Force aircraft; and h) disseminate results to the LAI community.

## Benefits

Improved processes, procedures and practices for the implementation of advanced technology into Air Force weapon systems, providing potential for saving millions of dollars on future advanced technology transition and insertion.

## Status

*Active*

*Start date: December 1997*

*End date: June 2001*

## Resources

*Project Engineer:*

*Laura Leising*

*AFRL/MLMP*

*(937) 255-2413*

*Air Force Funded*

*Contractor:*

*Boeing Company*

*JDMTP Subpanel:*

*Metals*

Metals

Metals

## Completed Projects

### Advanced Casting Technology for Low Cost Composites

(Page 157) Contract Number: F33615-97-C-5124 ALOG Number: 1550

**Technical Report Number: In Progress**

This STTR Phase I Small Business Innovation Research project was directed towards patternless molding as a method to significantly reduce cost and lead times of invariable lay-up tool casting by eliminating hard pattern equipment. Integrally cast stiffeners were investigated to create a method to reduce cost and lead time of tool substructures and to improve the heat transfer properties of the tools.

**Status**

*Complete*

*Start date: August 1997*

*End date: June 1998*

**Resources**

*Project Engineer:*

*Marvin Gale*

*AFRL/MLMP*

*(937) 255-7278*

*SBIR Funded*

*Contractor:*

*Waukesha Foundry Incorporated*

### Affordable Tooling for Composite Structures

(Page 158) Contract Number: F33615-97-C-5142 ALOG Number: 1551

**Technical Report Number: In Progress**

This Phase I Small Business Innovation Research program developed a new tooling system for composites, especially for affordable low production. The tooling system involves a novel two component system with a mold-face laminate and backup structure. The mold face laminate can be separated from an adjustable accurate backup structure.

**Status**

*Complete*

*Start date: August 1997*

*End date: August 1998*

**Resources**

*Project Engineer:*

*Marvin Gale*

*AFRL/MLMP*

*(937) 255-7278*

*SBIR Funded*

*Contractor:*

*Integrated Composites  
Incorporated*

### Affordable Tooling for Composite Structures

(Page 159) Contract Number: F33615-97-C-5144 ALOG Number: 1554

**Technical Report Number: In Progress**

New technologies and methodologies are needed to develop composite processing tools that are low cost, highly durable, have compatible thermal performance characteristics, and short fabrication lead times. The technical objective of this Phase I Small Business Innovation Research (SBIR) is to develop and demonstrate low cost tooling concepts to allow broad applications of the novel localized resistive heating technology.

**Status**

*Complete*

*Start date: May 1997*

*End date: May 1998*

**Resources**

*Project Engineer:*

*Vincent Johnson*

*AFRL/MLMP*

*(937) 255-7277*

*SBIR Funded*

*Contractor:*

*Production Products  
Manufacturing*

## Composite Manufacturing Process Control System

(Page 161) Contract Number: F33615-96-C-5627 ALOG Number: 1415

Technical Report Number: AFRL-ML-WP-TR-1998-4100

Process controls are one of the key elements of building quality into an organic matrix advanced composite structure. Built-in quality reduces inspection, rework and scrap costs, increases reliability and results in lower overall acquisition costs. The objective of this project was to produce and install production prototypes of a composite manufacturing process control system (CMPCS).

### Status

*Complete*

*Start date: May 1996*

*End date: May 1998*

### Resources

*Project Engineer:*

*Diana Carlin*

*AFRL/MLMP*

*(937) 255-7277*

*SBIR Funded*

*Contractor:*

*Assembly Guidance Systems*

## Design and Manufacture of Low Cost Composites -- Bonded Wing Initiative

(Page 162) Contract Number: F33615-91-C-5729 ALOG Number: 155

Technical Report Number: In Progress

The purpose of this program is to achieve a 50 percent reduction in the manufacturing cost of advanced composite structures with an attendant 25 percent reduction in the support cost. This effort developed the design/build technology necessary to reduce the cost of wing, fuselage, and engine structures for future aircraft. The program demonstrated the use of new emerging design, analysis, and manufacturing technologies implemented through a Concurrent Engineering/Integrated Product Development (CE/IPD) concept. The CE/IPD techniques developed within this initiative also demonstrated the capability to reduce support costs for future structures that use similar techniques.

### Status

*Complete*

*Start date: September 1991*

*End date: April 1998*

### Resources

*Project Engineer:*

*Vincent Johnson*

*AFRL/MLMP*

*(937) 255-7277*

*Air Force Funded*

*Contractor:*

*Bell Helicopter*

## Design and Manufacture of Low Cost Composites -- Engines Initiative

(Page 163) Contract Number: F33615-91-C-5719 ALOG Number: 173

Technical Report Number: In Progress

Emerging, innovative new concepts to improve advanced composite manufacturing capability will allow for innovative design techniques to reduce the acquisition cost of composite structures. This effort provided preliminary data by designing and manufacturing innovative advanced composite engine structures.

### Status

*Complete*

*Start date: August 1991*

*End date: September 1998*

### Resources

*Project Engineer:*

*Mike Waddell*

*AFRL/MLMP*

*(937) 255-7277*

*Air Force Funded*

*Contractor:*

*General Electric Company*

## Completed Projects

### Enhanced Pultruded Composite Materials

(Page 167) Contract Number: F33615-96-C-5629 ALOG Number: 1467

Technical Report Number: In Progress

Most pultrusion research studies to date examined simple pultruded shapes (e.g., simple flat or circular geometries), and have related processing conditions of these shapes to the expected mechanical properties of the composite. However, most design applications require products in more complex shapes, and unfortunately for composite materials, knowledge of composite material properties for simple shapes does not imply knowledge of the mechanical properties for the more complex shapes. Complex shaped composites need to be carefully designed for proper fiber placement and alignment, in addition to all those factors that normally affect pultruded composites. The objective of this effort was to manufacture composite materials in an optimized engineering design geometry.

#### Status

*Complete*

*Start date: May 1996*

*End date: April 1998*

#### Resources

*Project Engineer:*

*Vincent Johnson*

*AFRL/MLMP*

*(937) 255-7277*

*Air Force Funded*

*Contractor:*

*Rust College/University  
of Mississippi*

### Filmless Radiography for Aerospace Applications

(Page 171) Contract Number: F33615-97-C-5122 ALOG Number: 1547

Technical Report Number: In Progress

Radiography is frequently used to assess the quality of aerospace parts and assemblies and is used extensively at Air Force field and depot levels to evaluate the condition of in-service aircraft. This effort evaluated the feasibility to develop or modify a filmless radiography system with digital storage capability for aerospace structures and transition it to Air Force depots and field environments.

#### Status

*Complete*

*Start date: February 1997*

*End date: December 1997*

#### Resources

*Project Engineer:*

*Charles Buynak*

*AFRL/MLLP*

*(937) 255-9807*

*Air Force Funded*

*Contractor:*

*Liberty Technologies,  
Incorporated*

### Manufacturing Technology for Multifunctional Radomes

(Page 174) Contract Number: F33615-93-C-4312 ALOG Number: 655

Technical Report Number: In Progress

This program examined affordable solutions to the unique problems associated with radomes. It established and validate reproducible and affordable processes for the manufacture of low observable radomes. The specific goals were to meet current performance specifications while reducing the production costs, assembly variability, and production risks. This technology development is applicable to the retrofit of radomes for existing aircraft as well as advanced fighters with low radar cross-section.

#### Status

*Complete*

*Start date: September 1993*

*End date: September 1998*

#### Resources

*Project Engineer:*

*David Beeler*

*AFRL/MLMP*

*(937) 255-7277*

*Air Force Funded*

*Contractor:*

*Lockheed Advanced  
Development Company*

## Microwave Curing for Reversible Bonding of Composites

(Page 175) Contract Number: F33615-97-C-5139 ALOG Number: 1539

Technical Report Number: In Progress

The objective of this project was to use reversible polymeric adhesive bonding using variable frequency microwave energy. This would allow military and civilian aircraft manufacturers and operators to assemble, inspect and maintain their aircraft more cost-effectively. The focus of this general topic was to allow opportunities for major breakthroughs in the following areas: Composites Processing & Fabrication, Electronics Processing & Fabrication, Metals Processing & Fabrication, Advanced Industrial Practices, and Manufacturing & Engineering Systems. New processing techniques, variability reduction tools, affordability improvements, manufacturing simulation and modeling, are a few examples of the types of proposals desired. The emphasis was on innovation, the ability to achieve major advances and defense/commercial applicability.

### Status

*Complete*

*Start date: April 1997*

*End date: December 1997*

### Resources

*Project Engineer:*

*Vincent Johnson*

*AFRL/MLMP*

*(937) 255-7277*

*SBIR Funded*

*Contractor:*

*Aerotech Incorporated*

## Novel Low Cost Thermosets for Advanced Aerospace Composites

(Page 176) Contract Number: F33615-96-C-5628 ALOG Number: 1455

Technical Report Number: In Progress

This project significantly reduced the costs in advanced aerospace composite fabrication by using rational chemical design principles to engineer novel low temperature cure liquid crystal autoclave cure cycling.

### Status

*Complete*

*Start date: April 1996*

*End date: November 1998*

### Resources

*Project Engineer:*

*Vincent Johnson*

*AFRL/MLMP*

*(937) 255-7277*

*SBIR Funded*

*Contractor:*

*Aspen Systems Incorporated*

## Rapid Manufacture of Thermoplastic Radomes

(Page 178) Contract Number: F33600-90-G-5308 ALOG Number: 307

Technical Report Number: In Progress

This task developed a flight-capable prototype radome constructed of thermoplastic composite materials resistant to the chronic problems found in thermoset composite radomes. In addition, design data, processing procedures, manufacturing techniques, and quality assurance requirements were generated that are necessary for reliable and consistent fabrication of thermoplastic composite materials into solid and multilayer sandwich radomes. The data and processes validated and documented are applicable to a broad range of radome structures and systems.

### Status

*Complete*

*Start date: March 1993*

*End date: December 1997*

### Resources

*Project Engineer:*

*Mike Waddell*

*AFRL/MLMP*

*(937) 255-7277*

*Air Force Funded*

*Contractor:*

*E-Systems Incorporated*

## Completed Projects

### Resin Transfer Molding Rapid Prototyping and Tooling

(Page 179) Cooperative Agreement Number: F33615-95-2-5558 ALOG Number: 1471

Technical Report Number: In Progress

The objective of this effort is to reduce the cost and lead times to design and produce Resin Transfer Molding (RTM) prototype tooling and components. The program investigated rapid prototype tooling approaches such as: stereolithography, selective laser sintering, laminated object manufacturing, three-dimensional printing, direct shell production casting, metal deposition, cast tools, droplet deposition and laminate tools.

#### Status

*Complete*

*Start date: September 1995*

*End date: January 1998*

#### Resources

*Project Engineer:*

*Diana Carlin*

*AFRL/MLMP*

*(937) 255-7277*

*DARPA Funded*

*Contractor:*

*Dow-United Technologies*

*Composite Products, Inc.*

## Active Projects

### Dynamic Polymer Composites

(Page 166) Contract Number: F33615-97-C-5126 ALOG Number: 1536

**Update** - Decreasing defense budgets along with increasing commercial requirements necessitate the development of low cost organic matrix composite structures. A large percentage of the costs are associated with assembly and repair of composite structures. This project addresses applications design, manufacturing and cost impact. Structural connector will be tested to determine capabilities. The prototype will be field validated.

#### Status

*Active*

*Start date: April 1997*

*End date: April 1999*

#### Resources

*Project Engineer:*

*Vincent Johnson*

*AFRL/MLMP*

*(937) 255-7277*

*SBIR Funded*

*Contractor:*

*The Technology*

*Partnership*

### Field Level Repair/Joining of Composite Structures

(Page 169) Contract Number: F33615-97-C-5125 ALOG Number: 1537

**Update** - The objective of this project is to develop an ultrasonic repair/joining technique for field repair of advanced composite structures. The approach is to combine ultrasonic lamination and Z-fiber insertion into a qualified repair process for an advanced composite system such as the F-22. The program is scheduled to construct and demonstrate a prototype field repair unit.

#### Status

*Active*

*Start date: May 1997*

*End date: September 1999*

#### Resources

*Project Engineer:*

*Marvin Gale*

*AFRL/MLMP*

*(937) 255-7278*

*SBIR Funded*

*Contractor:*

*Foster-Miller Incorporated*

### Manufacture of Thermoplastic Composite Preferred Spares

(Page 173) Contract Number: F33615-91-C-5717 ALOG Number: 172

**Update** - The use of advanced composites in new weapon systems has dramatically increased. Advanced composites help achieve the desired goals of increased range, speed, payload, and supportability. This program focused on the use of computer-aided manufacturing technologies to develop and validate an integrated design/manufacturing system for noncritical structural components. This permits the Air Logistics Centers (ALCs) to efficiently redesign and develop composite secondary structure by providing an automated design and analysis capability.

#### Status

*Active*

*Start date: September 1991*

*End date: December 1998*

#### Resources

*Project Engineer:*

*David Beeler*

*AFRL/MLMP*

*(937) 255-7277*

*Air Force Funded*

*Contractor:*

*Northrop Grumman*

# Advanced Fasteners for Low Cost Airframe Assembly and Repair

Contract Number: F33615-97-C-5156

ALOG Number: 1589

Technical Report Number: In Progress

## Statement of Need

All future DoD weapons systems are being developed with major emphasis on achieving maximum performance at an acceptable cost. The airframe assembly operation represents a major portion of the overall manufacturing cost. Significant potential exists for lowering the cost of assembly by eliminating or reducing the need for drill tooling and pre-assembly fixtures. The development of advanced fasteners that relax hole tolerance requirements could substantially reduce cost associated with the fabrication, certification, and maintenance of high tolerance interchangeable/replaceable drill tooling. Advanced fasteners are required that allow for loose tolerance holes and provide adequate interface for high load transfer effectively. The new fastener technology should be applicable to both permanent and replaceable fasteners. Tensile strength, shear strength, weight and configuration of the advanced fasteners should satisfy the requirements of advanced fighters such as the F-22 or Joint Strike Fighter (JSF).

## Approach

The objective of this Phase I SBIR was to develop and demonstrate advanced fastener technology that will significantly reduce the cost of airframe assembly. In addition, the contractor evaluated the feasibility of using advanced fasteners to relax dimensional tolerance requirements and substantially reduce or eliminate associated tooling cost. The effort demonstrated a low-cost high performance fastener as an alternative to production fasteners. The design will allow relaxed tolerance for fastener holes as well as requiring fewer total fasteners. A series of tensile, shear, and fatigue tests were conducted.

## Benefits

The fastener design is potentially a stronger more affordable fastener for the assembly of metal and composite structures for advanced fighter aircraft.

Nonmetals

Nonmetals

## Status

*Complete*

*Start date: October 1997*

*End date: May 1998*

## Resources

*Project Engineer:*

*Marvin Gale*

*AFRL/MLMP*

*(937) 255-7278*

*SBIR Funded*

*Contractor:*

*Navmar Applied Science  
Corporation*

*JDMTP Subpanel:*

*Composites*

# Advanced Fasteners for Low Cost Airframe Assembly and Repair

Contract Number: F33615-97-C-5157

ALOG Number: 1592

Technical Report Number: AFRL-ML-WP-TR-1998-4098

## Statement of Need

All future DoD weapons systems are being developed with major emphasis on achieving maximum performance at an acceptable cost. The airframe assembly operation represents a major portion of the overall manufacturing cost. Significant potential exists for lowering the cost of assembly by eliminating or reducing the need for drill tooling and pre-assembly fixtures. The development of advanced fasteners that relax hole tolerance requirements could substantially reduce cost associated with the fabrication, certification, and maintenance of high tolerance interchangeable/replaceable drill tooling. Advanced fasteners are required that allow for loose tolerance holes and provide adequate interface for high load transfer effectively. The new fastener technology should be applicable to both permanent and replaceable fasteners. Tensile strength, shear strength, weight and configuration of the advanced fasteners should satisfy the requirements of advanced fighters. The objective of this Phase I SBIR was to develop and demonstrate advanced fastener technology that will significantly reduce the cost of airframe assembly.

## Approach

The approach was to evaluate prototype self-locking fasteners for advanced airframe assembly. This included mathematics and stress models as well as a series of shock and vibration tests. The contractor evaluated the feasibility of using advanced fasteners to relax dimensional tolerance requirements and substantially reduce or eliminate associated tooling cost.

## Benefits

The proposed fasteners design could provide more affordable, better performing fastening for advanced aircraft assembly.

## Status

*Complete*

*Start date: October 1997*

*End date: May 1998*

## Resources

*Project Engineer:*

*Marvin Gale*

*AFRL/MLMP*

*(937) 255-7278*

*SBIR Funded*

*Contractor:*

*Damona Service Company*

*JDMTP Subpanel:*

*Composites*

# Advanced Fasteners for Low Cost Airframe Assembly and Repair

Contract Number: F33615-98-C-5108

ALOG Number: 1607

Technical Report Number: In Progress

## Statement of Need

All future DoD weapons systems are being developed with major emphasis on achieving maximum performance at an acceptable cost. The airframe assembly operation represents a major portion of the overall manufacturing cost. Significant potential exists for lowering the cost of assembly by eliminating or reducing the need for drill tooling and pre-assembly fixtures. The development of advanced fasteners that relax hole tolerance requirements could substantially reduce cost associated with the fabrication, certification, and maintenance of high tolerance interchangeable/replaceable drill tooling. Advanced fasteners are required that allow for loose tolerance holes and provide adequate interface for high load transfer effectively. The new fastener technology should be applicable to both permanent and replaceable fasteners. Tensile strength, shear strength, weight and configuration of the advanced fasteners should satisfy the requirements of advanced fighters. The objective was to utilize a proven conformance fit fastener technology to demonstrate the feasibility of an advanced fastener system capable of joining airframe components with loose tolerance holes while maintaining high load transfer and joint stiffness.

## Approach

The approach was to develop advanced fastener concepts for both permanent and replaceable fasteners based on advanced fighter cost and performance requirements. The contractor developed a detail design of an advanced fastener and perform stress and fatigue analysis. Prototype fasteners were fabricated and screen tested to demonstrate concept feasibility.

## Benefits

This advanced fastener technology could be used to reduce the cost of commercial products such as airliners, business jets, high speed boats, et cetera. This technology would have wide commercial application and could be used to further reduce the cost of commercial products with mechanically fastened joints.

## Status

*Complete*

*Start date: December 1997*

*End date: June 1998*

## Resources

*Project Engineer:*

*Marvin Gale*

*AFRL/MLMP*

*(937) 255-7278*

*SBIR Funded*

*Contractor:*

*Materials Analysis*

*Incorporated*

*JDMTP Subpanel:*

*Composites*

Nonmetals

Nonmetals

# Breathable Release Coating for Ceramic Tooling

Contract Number: F33615-97-C-5154

ALOG Number: 1590

Technical Report Number: AFRL-ML-WP-TR-1998-4049

## Statement of Need

The use of castable ceramic tooling for fabrication of solvent-based composite parts requiring two-sided tooling has significant cost advantages if acceptable release materials are available. Solvent-based composite materials systems require manufacturing methods which allow in-situ removal of solvents. For parts which require tooling to one surface only, porous materials may be utilized on the non-tooled surface to allow permeation of the volatiles from the part. In the case of parts which require tooling on both surfaces, the tooling material itself must be sufficiently permeable to allow volatile removal and must be finished with an appropriate release coat or be inherently adhesion resistant to the composite material. For tooling materials which are not inherently adhesion resistant, the release coat must not only provide a mechanism for release of the composite part from the tool, but also a mechanism for permeation of the volatiles from the part and through the tooling material.

## Approach

The objective of this Phase I SBIR was to develop or modify a release coating for use with ceramic tooling capable of withstanding cure temperatures in excess of 700° F. This release coating is capable of providing both release and volatile removal for solvent-based composite materials which process at temperatures up to 750° F. The approach was to form a high temperature film forming silicone resin system capable of withstanding cure cycles in excess of 700° Fahrenheit. The main approach was to investigate improvements of silicone resins that were modified with phenyl siloxanes, fluoropolymers, and polyimides. The system was evaluated for thermal shock, adhesion, and permeability.

## Benefits

The program will make significant cost/performance improvements in the high temperature processing of advanced composites.

## Status

*Complete*

*Start date: October 1997*

*End date: March 1998*

## Resources

*Project Engineer:*

*Marvin Gale*

*AFRL/MLMP*

*(937) 255-7278*

*SBIR Funded*

*Contractor:*

*Utility Development*

*Corporation*

*JDMTP Subpanel:*

*Composites*

# Computer Enhanced Eddy Current Detection of Hidden Substructures, Edges and Holes

Nonmetals

Contract Number: F33615-98-C-5107

ALOG Number: 1608

## Statement of Need

The assembly of aircraft structure involves precision alignment of skins to substructure (bulkheads, frames, spars/ribs, etc.) prior to the drilling and filling of fastener holes. All hole locations and edge distances are constrained to tight tolerances to achieve the lightest structural weight, highest structural integrity, and the lowest radar signature. Closely matched holes that fit snugly to the fasteners at the minimum allowable distance from the panel's and substructure's edge are desired. The current methods for locating holes and edges requires the assembly technician to use hard templates or to view the assembly from the underside to mark the outer skin with edge and hole location markings. Often excess material and edge distances are required to compensate for alignment inaccuracies. Low cost innovative equipment and techniques are needed that provide the assembly technician with accurate and timely information on the edge and hole locations of hidden substructure relative to mating outer skins. This information should include a visual display or markings to assist the aircraft assembly technician in drilling properly aligned holes and verifying edge distance requirements.

## Approach

Technical activity is complete the final report (Computer Enhanced Eddy Current Detection of Hidden Substructure Edges and Holes, July 1998) was sent to STINFO July 15, 1998. This Small Business Innovation Research Phase I project was directed toward reducing aircraft assembly cost and time by developing innovative equipment to locate edges and holes in substructures that are hidden under metal or composite exterior panels and skins. Manual methods are now employed to transfer the location of fastener holes in the substructure relative to mating outer skins. To address this problem of reducing assembly costs while enhancing fastener alignment, ARCOVA has established the feasibility of a hand-held, all-digital eddy current instrument for improved detection and mapping of multilayer aircraft structures. The Phase I project demonstrated the feasibility of using eddy currents to detect subsurface gaps, holes and indentations in a number of sample configurations. The contractor applied digital signal processing technology to develop an advanced eddy current instrument capable of monitoring voltage and current waveforms derived from hidden substructures.

## Benefits

The ability to sense and display hidden structure has a profound impact on both commercial and military markets. Significant cost reductions could be realized in assembly operations; which is the largest single cost area associated with the manufacture of commercial and military aircraft.

## Status

*Active*

*Start date: August 1998*

*End date: August 2000*

## Resources

*Project Engineer:*

*Vincent Johnson*

*AFRL/MLMP*

*(937) 255-7277*

*SBIR Funded*

*Contractor:*

*American Research*

*Corporation of Virginia*

*JDMTP Subpanel:*

*Composites*

Nonmetals

# Composites Affordability Initiative

## Phase II - Pervasive Technology/Seattle

Cooperative Agreement Number: F33615-98-3-5103

ALOG Number: 1624

### Statement of Need

The Composites Affordability Initiative (CAI) is being structured as an agreement between the government and industry to jointly attack the issues and areas of cost associated with the use of composite materials in military systems. The DoD, primarily the Air Force and the Navy, are participating with the four major airframe manufacturers, Boeing, Lockheed Martin, Northrop Grumman and Boeing Company (formerly McDonnell Douglas), in an effort to jointly develop and mature the essential design and manufacturing processes to achieve major cost reductions in composites. This will be accomplished by addressing issues which cross the boundaries of cultural, business and technology domains from both the perspective of the government and industry. The management team will be structured as a Leadership Integrated Product Team (LIPT) utilizing the principles of IPPD to accomplish required tasks via focus activity IPTs created to address specific topic areas/issues. This team will have total responsibility for the direction of the effort and all the member resources assigned to the program.

### Approach

Initially, the CAI will focus on fixed wing attack aircraft as they represent the most costly and structurally challenging use of composites. However, the results will be applicable to other aircraft systems, both military and commercial, and could enhance composites use in ground vehicle and ship applications.

### Benefits

CAI activity will result in a major reduction in the cost of composite structures and expand their application in military systems which can only be accomplished in collaborative effort between the government and industry. The active involvement of all parties, collaborative planning and shared development, early and frequent demonstrations with opportunities for early transition to production is the selected approach to gain wide acceptance of the proposed new revolutionary airframe design and manufacturing processes.

### Status

*Active*

*Start date: January 1998*

*End date: January 2001*

### Resources

*Project Engineer:*

*Ken Ronald*

*AFRL/MLMP*

*(937) 255-7278*

*Contractor:*

*Boeing Company*

*JDMTP Subpanel:*

*Composites*

# Composites Affordability Initiative

## Phase II - Pervasive Technology/Lockheed

Cooperative Agreement Number: F33615-98-3-5105

ALOG Number: 1625

### Statement of Need

The Composites Affordability Initiative (CAI) is being structured as an agreement between the government and industry to jointly attack the issues and areas of cost associated with the use of composite materials in military systems. The DoD, primarily the Air Force and the Navy, are participating with the four major airframe manufacturers, Boeing, Lockheed Martin, Northrop Grumman and Boeing Company (formerly McDonnell Douglas), in an effort to jointly develop and mature the essential approaches to achieve major cost reductions in composites. This will be accomplished by addressing issues which cross the boundaries of cultural, business and technology domains from both the perspective of the government and industry. The management team will be structured as a Leadership Integrated Product Team (LIPT) utilizing the principles of IPPD to accomplish required tasks via focus activity IPTs created to address specific topic areas/issues. This team will have total responsibility for the direction of the effort and all the member resources assigned to the program.

### Approach

Initially, the CAI will focus on fixed wing attack aircraft as they represent the most costly and structurally challenging use of composites. However, the results will be applicable to other aircraft systems, both military and commercial, and could enhance composites use in ground vehicle and ship applications.

### Benefits

CAI activity will result in a major reduction in the cost of composite structures and expand their application in military systems which can only be accomplished in collaborative effort between the government and industry, the product and the customer. The active involvement of all parties, collaborative planning and shared development, early and frequent demonstrations with opportunities for early transition to production is the only approach to gain wide acceptance of the proposed new revolutionary airframe approaches.

### Status

*Active*

*Start date: January 1998*

*End date: March 2001*

### Resources

*Project Engineer:*

*Frances Abrams*

*AFRL/MLMP*

*(937) 255-7277*

*Contractor:*

*Lockheed Martin  
Corporation*

*JDMTP Subpanel:*

*Composites*

Nonmetals

Nonmetals

# Composites Affordability Initiative

## Phase II - Pervasive Technology/St. Louis

Cooperative Agreement Number: F33615-98-3-5104

ALOG Number: 1626

### Statement of Need

The Composites Affordability Initiative (CAI) is being structured as an agreement between the government and industry to jointly attack the issues and areas of cost associated with the use of composite materials in military systems. The DoD, primarily the Air Force and the Navy, are participating with the four major airframe manufacturers, Boeing, Lockheed Martin, Northrop Grumman and Boeing Company (formerly McDonnell Douglas), in an effort to jointly develop and mature the essential approaches to achieve major cost reductions in composites. This will be accomplished by addressing issues which cross the boundaries of cultural, business and technology domains from both the perspective of the government and industry. The management team will be structured as a Leadership Integrated Product Team (LIPT) utilizing the principles of IPPD to accomplish required tasks via focus activity IPTs created to address specific topic areas/issues. This team will have total responsibility for the direction of the effort and all the member resources assigned to the program.

### Approach

Initially, the CAI will focus on fixed wing attack aircraft as they represent the most costly and structurally challenging use of composites. However, the results will be applicable to other aircraft systems, both military and commercial, and could enhance composites use in ground vehicle and ship applications.

### Benefits

CAI activity will result in a major reduction in the cost of composite structures and expand their application in military systems which can only be accomplished in collaborative effort between the government and industry, the product and the customer. The active involvement of all parties, collaborative planning and shared development, early and frequent demonstrations with opportunities for early transition to production is the only approach to gain wide acceptance of the proposed new revolutionary airframe approaches.

### Status

*Active*

*Start date: January 1998*

*End date: March 2001*

### Resources

*Project Engineer:*

*Frances Abrams*

*AFRL/MLMP*

*(937) 255-7277*

*Contractor:*

*Boeing Company*

*JDMTP Subpanel:*

*Composites*

# The Composites Affordability Initiative

Cooperative Agreement Number: F33615-98-3-5106

ALOG Number: 1628

Nonmetals

## Statement of Need

The Composites Affordability Initiative (CAI) will be a collaborative effort between the Government and industry to jointly attack the issues and areas of cost associated with the use of composites materials. The Department of Defense, primarily the Air Force and the navy, will participate along with the four major airframe manufactures — Boeing Seattle, Lockheed Martin, Northrop Grumman, and Boeing St. Louis- in a collaborative effort to jointly develop and mature the essential design and manufacturing processes to achieve major cost reductions in composite structures. This will be accomplished by addressing issues which cross the boundaries of cultural, business and technology domains from both the perspective of the Government and industry. Initially, the CAI will focus on fixed wing attack aircraft as they represent the most costly and structurally challenging use of composites. However, the results will be applicable to other aircraft systems, both military and commercial, and could enhance composites use in ground vehicle and ship applications.

## Approach

The overarching goal of the Composites Affordability Initiative (CAI) is to significantly reduce the acquisition costs of airframe structures through the revolutionary utilization of composites materials. The specific goal of this effort (Phase II) is to develop the tools and technologies necessary to enable integrated product teams to confidently design, manufacture and integrate with aircraft subsystems an “all-composites” airframe utilizing revolutionary design techniques, innovative manufacturing concepts, materials, processes and advanced business practices, to enable breakthrough reductions in cost, schedule and weight. Initial CAI emphasis will be placed on Joint Strike Fighter (JSF) insertion opportunities.

## Benefits

The overarching goal of the Composites Affordability Initiative (CAI) is to significantly reduce the acquisition costs of airframe structures through the revolutionary utilization of composites materials.

Nonmetals

## Status

*Active*

*Start date: January 1998*

*End date: October 2000*

## Resources

*Project Engineer:*

*Ken Ronald*

*AFRL/MLMP*

*(937) 255-7278*

*Contractor:*

*Northrop-Grumman*

*JDMTP Subpanel:*

*Composites*

# Developing a Flexible Mandrel and Semi-Flexible Tooling for the Fabrication of Integrated Composite Structures

Contract Number: F33615-97-C-5152

ALOG Number: 1560

Technical Report Number: In Progress

## Statement of Need

Organic matrix composites structural technology impacts virtually every current and new weapon system. These structures provide critical performance enhancements which enable the DoD to field superior weapons systems. Although organic matrix composites are used in a wide spectrum of vehicle structures, the high cost of these structures may severely limit the implementation of this critical technology to its fullest potential. Therefore, new technologies which allow for the affordable implementation of composite structures must be pursued. Tooling costs have been identified as a high cost area especially in the prototype environment and as production rates continue to drop. Composite cure tools must produce dimensionally accurate parts, (match the coefficient of thermal expansion (CTE) of the part), be affordable to demonstrate the tooling approach in a prototype environment, and be durable enough to meet the requirements of production use. INVAR tools have been shown to meet thermal and durability requirements and are being used extensively on ongoing aircraft production programs. However, INVAR tooling is very expensive and requires significant fabrication lead times. New technologies and methodologies are needed to develop composite processing tools that are low cost, highly durable, have compatible thermal performance characteristics, and short fabrication lead times. The new tooling technology and methodology should address the cost of fabricating both the tool face and substructure. It must provide all the capabilities of internal tooling points, scribe lines, and vacuum ports as available on current INVAR cure tools.

## Approach

The objective was to reduce the high cost of tooling for complex integrated composite structures. The tooling can be re-used, thus making the manufacturing method cost effective. The contractor used a flexible mandrel and tool for manufacturing integrated composite structures. RTM-resin transfer molding, or tape laying can be used with this tooling approach.

## Benefits

The payoff for this project was to demonstrate the feasibility of this low cost tooling approach.

## Status

*Complete*

*Start date: August 1997*

*End date: August 1998*

## Resources

*Project Engineer:*

*Ken Ronald*

*AFRL/MLMP*

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*SBIR Funded*

*Contractor:*

*Wright Materials*

*Research Company*

*JDMTP Subpanel:*

*Composites*

# Hybrid Composites Manufacturing Braiding/ Filament Winding Production

Nonmetals

Contract Number: F33615-98-C-5101

ALOG Number: 1603

Technical Report Number: In Progress

## Statement of Need

Under the Air Force Mantech program Design and Manufacture of Low Cost Composites (DMLCC) Engine, a hybrid composite manufacturing technology was developed involving braided and filament wound preform fabrication. The braided/filament wound hybrid composites are proving to be an effective means for fabricating critical, primary load bearing jet engine structures such as a center bypass duct. This is a straight axis part involving both braiding and filament winding with multiple features. Similar work has been done demonstrating the viability of braiding for low cost composite structures in the DMLCC Wing program as well as in wing and fuselage structures in the NASA ACT program. Currently, the braiding and filament winding processes are done on separate machines, necessitating two machines, removal from one machine to the next, shipment to separate facilities, et cetera. By combining or hybridizing the two processes into a single machine, significant process improvements and cost savings can be realized. The objective was to develop a detailed design, along with potential benefits, of a integrated multi axis preform manufacturing system.

## Approach

This project determined the potential savings and machine requirements for a multi axis preform manufacturing system of branding and filament winding volumes. It developed a conceptual design of such a machine and accomplished a feasibility test on a prototype system.

## Benefits

The fully integrated multi-axis preforming system will have applications in a myriad of industries. In the aerospace industry, it would be ideal for the production of the center bypass duct that has been the focus of the DMLCC Engine program, as well as for the manufacture of non-linear parts such as ducts and fuselage ribs. This technology would also be applicable to a variety of commercial industries such as automotive, medical (prosthetics), sports (hockey sticks, racket sports) and recreation equipment (bicycle components).

Nonmetals

## Status

*Complete*

*Start date: July 1998*

*End date: July 2000*

## Resources

*Project Engineer:*

*Marvin Gale*

*AFRL/MLMP*

*(937) 255-7278*

*SBIR Funded*

*Contractor:*

*A&P Technology*

*Incorporated*

*JDMTP Subpanel:*

*Composites*

# Hybrid Composites Manufacturing Technology for Braiding Filament Production

Contract Number: F33615-98-C-5100

ALOG Number: 1620

Technical Report Number: In Progress

## Statement of Need

Under the Air Force Mantech program Design and Manufacture of Low Cost Composites (DMLCC) Engine, a hybrid composite manufacturing technology was developed involving braided and filament wound preform fabrication. The braided/filament wound hybrid composites are proving to be an effective means for fabricating critical, primary load bearing jet engine structures such as a center bypass duct. This is a straight axis part involving both braiding and filament winding with multiple features. Similar work has been done demonstrating the viability of braiding for low cost composite structures in the DMLCC Wing program as well as in wing and fuselage structures in the NASA ACT program. Currently, the braiding and filament winding processes are done on separate machines, necessitating two machines, removal from one machine to the next, shipment to separate facilities, et cetera. By combining or hybridizing the two processes into a single machine, significant process improvements and cost savings can be realized. The objective was to determine current preform cost and potential cost savings and design an integrated/hybridized/automated manufacturing system for braided/filament wound preforms.

## Approach

The contractor built on the work done by Boeing (including McDonnell Douglas) and General Electric that was completed in the Design and Manufacture of Low Cost Composites programs along with the work at Clemson University to investigate the potential of undercoating the braiding and filament winding process.

## Benefits

The fully integrated multi-axis preforming system will have applications in a myriad of industries. In the aerospace industry, it would be ideal for the production of the center bypass duct that has been the focus of the DMLCC Engine program, as well as for the manufacture of non-linear parts such as ducts and fuselage ribs. This technology would also be applicable to a variety of commercial industries such as automotive, medical (prosthetics), sports (hockey sticks, racket sports) and recreation equipment (bicycle components).

## Status

*Complete*

*Start date: December 1997*

*End date: May 1998*

## Resources

*Project Engineer:*

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*AFRL/MLMP*

*(937) 255-7277*

*SBIR Funded*

*Contractor:*

*Production Products*

*Manufacturing and Sales*

*JDMTP Subpanel:*

*Composites*

# Porous Sol-Gel Derived Ceramic Release Agent

Nonmetals

Contract Number: F33615-97-C-5155

ALOG Number: 1591

Technical Report Number: AFRL-ML-WP-TR-1998-4048

## Statement of Need

The use of castable ceramic tooling for fabrication of solvent-based composite parts requiring two-sided tooling has significant cost advantages if acceptable release materials are available. Solvent-based composite materials systems require manufacturing methods which allow in-situ removal of solvents. For parts which require tooling to one surface only, porous materials may be utilized on the non-tooled surface to allow permeation of the volatiles from the part. In the case of parts which require tooling on both surfaces, the tooling material itself must be sufficiently permeable to allow volatile removal and must be finished with an appropriate release coat or be inherently adhesion resistant to the composite material. For tooling materials which are not inherently adhesion resistant, the release coat must not only provide a mechanism for release of the composite part from the tool, but also a mechanism for permeation of the volatiles from the part and through the tooling material. The objective of this Phase I SBIR was to develop or modify a release coating for use with ceramic tooling capable of withstanding cure temperatures in excess of 700° F.

## Approach

TPL developed innovative sol-gel routes to produce a porous ceramic coating as a release agent which can function at temperatures up to 750° Fahrenheit. The coating is compatible with solvents and materials used in composite processing, adheres strongly to the tool surface, and permits passage of volatiles. The coating was evaluated for release of thermal shock, thermal cycling, adhesion and porosity characteristics.

## Benefits

The release coating will improve quality and lower processing cost for solvent-based composites in addition to providing new performance capabilities for composites processing such as closed ceramic resin transfer molding tools.

Nonmetals

## Status

*Complete*

*Start date: September 1997*

*End date: March 1998*

## Resources

*Project Engineer:*

*Marvin Gale*

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*(937) 255-7278*

*SBIR Funded*

*Contractor:*

*TPL Incorporated*

*JDMTP Subpanel:*

*Composites*

# Advanced Material Processing Initiatives

Contract Number: F33615-94-D-5801

ALOG Number: 1609

## Statement of Need

Using principles of computer science, material science, and other engineering disciplines as appropriate, scientific methods will be developed for designing and controlling selected manufacturing processes such as chemical vapor deposition, isothermal forging, investment casting, and nonconventional machining operations. These methods will be based upon systematic, multidisciplinary approaches which consider material behavior, process mechanics, equipment characteristics, and production requirements associated with the manufacture of advanced aerospace components. Also, these methods will employ advanced computer technologies such as artificial intelligence based approaches for self-directing and self-improving design and control systems. The scientific methods will be validated and demonstrated by using laboratory and pilot-plant processing experiments.

## Approach

The specific objectives are: 1) develop self-directing and self-improving systems for real-time control of advanced material processes; 2) develop a memory driven, feature-based design system that integrates product and process design tasks; and 3) demonstrate self-improvement paradigms using a materials processing platform.

## Benefits

The goal of this program is to advance the state-of-the-art for manufacturing processes of existing and future aerospace systems such that significant benefits in quality, costs and lead time can be realized.

## Status

*Active*

*Start date: December 1994*

*End date: July 1999*

## Resources

*Project Engineer:*

*Steven LeClair*

*AFRL/MLMR*

*(937) 255-8786*

*Contractor:*

*Technical Management*

*Concepts Incorporated*

# Automated Data Acquisition for In-Situ Material Process Modeling

Contract Number: F33615-97-C-5841

ALOG Number: 1703

## Statement of Need

Knowledge regarding the interdependency of material, process, and shape for processing functionally gradient materials is progressing at a rate faster than the processing technology and process researchers and/or operators are capable of observing and in amounts of information far exceeding what a human can digest. This requires that the versatility of the processing equipment be utilized to its complete potential to augment the researcher and/or process operator in adapting to ever-changing processing conditions. Empirical data acquisition, storage and representation is crucial to system/operator interaction in directing the process discovery, responding to varying process conditions and subsequently to validate model refinements and new processing knowledge.

## Approach

The objective of this Phase II SBIR is to first design the data acquisition and process control system around a general purpose micro-kernel to maximize real-time capabilities. Then, combine process modeling and simulation, together with data exploration and discovery to improve the quality and lower the costs of processing advanced thin film materials. The approach is to (1) implement a micro-kernel design for the InfoScribe data acquisition system, (2) implement modeling methodologies to support off-line and on-line data exploration via simulation, and (3) assess the process modeling and control system through instrumentation and application to a number of processes.

## Benefits

The developed technology would have broad commercial appeal in improving the quality and lowering the costs of processing advanced thin film materials ranging from electro-optical materials for semiconductors, superconductors, thin-film displays, etc. to advanced multi-layer coatings for commercial aircraft and engine systems. All of these commercial applications have analogous opportunities to extend product thermal/fatigue limits with advanced processing, but are constrained by affordability considerations similar to those faced by the DoD.

## Status

*Active*

*Start date: May 1997*

*End date: May 1999*

## Resources

*Project Engineer:*

*David Conrad*

*AFRL/MLMR*

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*SBIR Funded*

*Contractor:*

*Infoscribe Technologies Ltd.*

Materials Process Design

Materials

# Intelligent Processing of Materials for Chemical Vapor Infiltration

Contract Number: F33615-96-C-5839

ALOG Number: 1618

## Statement of Need

When applied to chemical vapor infiltration (CVI) processing, the proposed process controls would have major impact on reducing products costs by increasing product quality and reproducibility. Additional cost reduction would follow from the competition engendered by the wide spread dissemination through the private sector of CVI technology that would result from a more reliable and controllable process. Furthermore, due to the process model independence of the IPM system, the potential for spin off applications to a wide variety of other processing requirements, such as for CVD, PLD, PVD, MBE and composite cure, is very considerable. Thus, IPM could be an enabling technology for a variety of materials processes which currently are too costly to be economically viable across a wide commercial spectrum.

## Approach

During the Phase I effort, an integrated, three-level intelligent processing of materials (IPM) control approach was developed. The components of that approach were: a hierarchical control structure, a process model and an in situ sensor. During the Phase II effort, software for the three-level hierarchical control structure will be developed including the process model to train a rapid convergence artificial neural network (ANN) for dynamically identifying the process trajectory and redirecting the process in real-time, the in situ sensor to provide materials processing data in real-time, and a process supervisor and health monitor will complete the control system. This integrated control system then will be used for CVI processing of SiC CMCs to further train the ANN and refine the processing model.

## Benefits

The objective of this Phase II SBIR is the implementation of an integrated, three level IPM controls system for microwave and FR heated chemical vapor infiltration (CVI) system, and the corresponding development of appropriate in-situ sensors necessary to affect control.

## Status

*Active*

*Start date: December 1996*

*End date: December 1998*

## Resources

*Project Engineer:*

*Claudia Kropas-Hughes*

*AFRL/MLMP*

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*SBIR Funded*

*Contractor:*

*Technology Assessment*

*and Transfer Incorporated*

# Interactive Simulation System for Design of Multi-Stage Manufacturing Technology

## Materials Process Design

Materials

Contract Number: F33615-97-C-5842

ALOG Number: 1611

Technical Report Number: AFRL-ML-WP-TR-1998-4047

### Statement of Need

Materials insertion applications and spare components for aging aircraft systems offer tremendous opportunity to introduce innovative methods, processes and material systems to reduce weight and costs while improving wear, temperature and strength performance. The need is for material process design methods which consider alternative processing which lead to significant reduction in design and fabrication times. Of particular interest is the design and fabrication of precision tooling to enable materials substitution or replacement components that are lighter, stronger and less expensive than might be otherwise attained through conventional forging, casting and machining operations. Demonstration of reduced part turnaround and delivery with cost savings of 50 percent are a targeted goal. Methods, processes and materials should be functionally integrated via a feature-based design environment allowing selection and optimization of manufacturing methods, processes, and materials for structural aircraft and engine components. Feasibility was demonstrated starting with metal forming processes by embedding the analytical model of basic transport phenomena into design models that include geometric, microstructure, and processing features.

### Approach

The purposes of the effort were to develop a computer platform for simulation- and optimization-based design of multiple-stage manufacturing processes, to explore the market for this platform, to define the system architecture, to identify model sources, and to demonstrate the feasibility of the approach. An exploration of prospective users showed needs for systematic computer tools for preliminary product and process design that can evaluate alternate manufacturing sequences and parameters for quality, performance, and cost. Sources of material and process models were identified. Simplified analytical models of several metal forming processes were used to simulate sequences of operations for the production of sample engine disks. Process and cost models and an optimization algorithm were integrated into software modules that execute in multiple Win32-based computers and display results in multiple monitors. Displayed results include geometry, process parameters, and cost information, and show the effects of geometry and process changes on cost, and the optimization algorithm's tradeoffs. Further development will use an adaptive modeling language with object oriented, feature based, graphics and world wide web capabilities. Potential applications include defense and industrial use in integrated product and process design and affordability efforts, and research and academic use in experimentation with new processes and materials and in training.

### Benefits

Dual use of this exploratory research is foreseen for integrated shape, material, and process design of high performance metals, ceramics and polymers. Aircraft and automobile propulsion system vendors will provide tooling for forming new higher temperature alloys. The integration of virtual metal forming stages will provide users with important information about interdependencies among manufacturing stages, and allow for more cost-effective optimizations of complex manufacturing operations.

### Status

*Complete*

*Start date: May 1997*

*End date: February 1998*

### Resources

*Project Engineer:*

*David Conrad*

*AFRL/MLMR*

*(937) 255-8786*

*SBIR Funded*

*Contractor:*

*Austral Engineering*

# Large Area Pulsed Laser Deposition and Intelligent Process Control for Production Applications

Contract Number: F33615-96-C-5834

ALOG Number: 1615

Technical Report Number: In Progress

## Statement of Need

During the Phase I Program it was determined that over 260 different materials have been deposited by Pulsed Laser Deposition (PLD) clearly indicating that this process is emerging as a tool with which to deposit a wide variety of chemical compounds. However, since the process is relatively new, there is a clear lack of infrastructure to address emerging applications which will require large-area production compatible equipment. One such emerging application which could be addressed by PLD is that of high temperature superconducting filters for the mobile communications industry. This Phase II SBIR will strive to significantly improve the infrastructure for the PLD process by developing a fully integrated prototype large-area machine capable of depositing YBCO material over a 5-inch diameter area with a film quality compatible with the above mentioned application. Furthermore, the contractor will develop several unique tools with which to monitor and control this process including: a deposition rate monitor based on atomic absorption, a computer controlled Intelligence Window, intelligent process control software, and a unique oxygen resistant substrate heater. Each of these tools will significantly improve the infrastructure for the PLD process and lead to products in themselves.

## Approach

A prototype large area PLD machine was built. Laser beam rastering was used to deposit films over a large area diameter. Systems were developed to monitor the excimer laser, the constant fluence optical train, the target manipulator, gas pressure control package, substrate temperature regulation, and atomic absorption deposition rate monitor. The entire PLD machine is controlled by using the Infoscrite software package developed at Air Force Research Laboratory.

## Benefits

The objective of this Phase II SBIR was to develop a fully integrated prototype large area PLD machine capable of depositing YBCO material over a five inch diameter area with a film quality compatible for use as high temperature superconducting filters in the mobile communication industry. Such a unit will provide intelligent closed-loop process control of relevant parameters for reproducible film growth, i.e., deposition rate and on-target laser fluency, thus making PLD a production-worthy film growth process.

## Status

*Complete*

*Start date: May 1996*

*End date: September 1998*

## Resources

*Project Engineer:*

*David Conrad*

*AFRL/MLMR*

*(937) 255-8786*

*SBIR Funded*

*Contractor:*

*PVD Products*

# Laser Cleaning and Coatings Removal (LCCR)

Contract Number: F33615-95-C-5515

ALOG Number: 1230

Technical Report Number: In Progress

## Statement of Need

Cleaning and coatings removal technologies have traditionally depended upon the use of organic solutions, such as PD 680 (I, II, & III), methyl ethyl ketone (MEK), methylene chloride (MECL), phenol, and strong acids and bases as well as hot potassium permanganate solutions. These materials are hazardous, and include volatile organic compounds (VOCs), ozone depleting chemicals (ODCs) and air toxic emitters which are subject to severe restrictions or are being banned altogether, such as freon (CFC-113). More recently, the trend in cleaning technology is toward the use of water based cleaners (sodium metasilicate, bases, terpene/water emulsions or water detergent blends), some of which may be hazardous to some degree. However, technologies are needed which do not involve generation of waste water streams. Laser-based cleaning and coating removal has been demonstrated to be an environmentally acceptable, affordable and controllable technology. A demonstration facility is needed to facilitate transition of this technology to Air Force, Department of Defense and industry use, targeted to the immediate needs of the Air Logistics Centers.

## Approach

The project approach is to design, fabricate, test, evaluate and demonstrate a state-of-the-art automated, controllable laser cleaning and coating removal facility. The facility will be designed for carbon dioxide and eximer laser cleaning and coating removal operations. System operation will be fully robotized and computer controlled with on-line instrumentation for component positioning and measuring and controlling laser inputs to the part surfaces.

## Benefits

The goal of this effort is to provide a field demonstration of a prototype laser-based facility to demonstrate environmentally acceptable component cleaning and coating removal technology and to transition it to aerospace users. The laser-based cleaning and coating removal facility is applicable to a broad range of aircraft and general equipment cleaning and coatings removal work. Benefits include the complete elimination of the use of toxins and hazardous waste generation in logistic center maintenance and re-manufacturing operations relying on the new technology.

## Status

*Terminated*

*Start date: May 1995*

*End date: May 1998*

## Resources

*Project Engineer:*

*Steve Fairchild*

*AFRL/MLMR*

*(937) 255-8786*

*Contractor:*

*F2 Associates Incorporated*

# Materials Processing Technology Initiatives

Contract Number: F33615-96-D-5835

ALOG Number: 1619

Technical Report Number: In Progress

## Statement of Need

This program advanced in-house materials processing (design and control) research which encompasses non-structural tribological coatings and inorganic (though biologically based) electro-optical materials; and structural metal alloys, intermetallics, polymer, metal and ceramic composites in the direction of virtual materials research by the 21st century. Research in areas such as high and low cycle fatigue, non-destructive inspection, super alloys and intermetallics research will benefit from electronic access to Air Logistic Centers's engine inspection results on a continuing basis and evolving both material and processing research in near real-time towards the immediate needs of aging systems.

## Approach

Research addressed advanced computing and engineering methods for automated materials process analysis, synthesis and discovery, integrated materials-shape-process design and self-directed materials process control. In-house research was transitioned through innovative and novel "need/problem-specific" enhancements and extensions to existing technology. Such enhancements and/or extensions involved interdisciplinary and cross-functional collaboration with Air Force and other customers as well as other federal and state agencies, and defense industrial sectors. The research strategy is to collaborate with other government and industrial organizations with specific technology needs that have the potential to benefit from on-going research results and to facilitate the enhancement and extension of those results.

## Benefits

The goal of this program was to advance computational methods toward virtual materials and processing research such that significant improvements in research quality (improved atomic-scale control of thin-film technology), costs (more affordable alternative materials and processes) and response time (to accelerate the current 15 year cycle from concept to validation of new weapon system materials) while enhancing technology investments that have been made in the state-of-the-art for materials processing of existing and future aerospace systems. Also, to enable (by means of a materials and processing information highway) transition and transfer of materials processing technology more effectively and to a more pervasive set of applications.

## Status

*Complete*

*Start date: September 1996*

*End date: March 1998*

## Resources

*Project Engineer:*

*Steven LeClair*

*AFRL/MLMR*

*(937) 255-8786*

*Air Force Funded*

*Contractor:*

*Technical Managements*

*Concepts Incorporated*

# Novel Processing of Co-Continuous Alpha-Alumina/Beta-Nickel

Contract Number: F33615-97-C-5843

ALOG Number: 1612

Technical Report Number: AFRL-ML-WP-TR-1998-4046

## Statement of Need

Materials insertion applications and spare components for aging aircraft systems offer tremendous opportunity to introduce innovative methods, processes and material systems to reduce weight and costs while improving wear, temperature and strength performance. The need is for material process design methods which consider alternative processing which lead to significant reduction in design and fabrication times. Of particular interest is the design and fabrication of precision tooling to enable materials substitution or replacement components that are lighter, stronger and less expensive than might be otherwise attained through conventional forging, casting and machining operations. Demonstration of reduced part turnaround and delivery with cost savings of 50 percent are a targeted goal. Methods, processes and materials should be functionally integrated via a feature-based design environment allowing selection and optimization of manufacturing methods, processes, and materials for structural aircraft and engine components.

## Approach

A variety of processing methods were attempted in the pursuit of producing a successful beta NiAl/Al<sub>2</sub>O<sub>3</sub> composite material. The High Temperature Solvent Exchange (HTSX) process and NiAl<sub>2</sub>O<sub>4</sub>-RISP processes were successfully used to produce the desired Co-Continuous Ceramic Composite (C4) materials. Samples of the HTSX materials were subjected to a variety of physical and mechanical behavior evaluations. Results of these tests indicate that the materials have a density of 4.3 g/cm<sup>3</sup>, a hardness of approximately 59Rc, an elastic modulus of approximately 205 GPa, a bend strength of approximately 250 MPa, and a Weibull modulus of 15.6. This Phase I SBIR research identified suitable processing routes, fabricate test specimens from each route, and statistically characterized mechanical and microstructural properties of significant samples.

## Benefits

Dual use of this exploratory research is foreseen for integrated shape, material, and process design of high performance metals, ceramics and polymers. Aircraft and automobile propulsion system vendors will provide tooling for forming new higher temperature alloys. This exploratory development program attempted to develop the necessary technology for the in-situ fabrication of near net-shaped composite structures comprised of Alpha-Al<sub>2</sub>O<sub>3</sub> and Beta-NiAl.

## Status

*Complete*

*Start date: May 1997*

*End date: February 1998*

## Resources

*Project Engineer:*

*David Conrad*

*AFRL/MLMR*

*(937) 255-8786*

*SBIR Funded*

*Contractor:*

*BFD Incorporated*

# Process Optimization and Integration of Materials and Process Properties: Demonstrated with CVD and MBE Experiments

Contract Number: F33615-95-C-5823

ALOG Number: 1616

Technical Report Number: AFRL-ML-WP-TR-1998-4039

## Statement of Need

Global competition in manufacturing, limitations in fiscal and physical resources, ecological constraints, and technically challenging mission goals require that productivity be increased in the design, fabrication, and utilization of new or improved materials. The technical approach is based on unified learning and interpretation of combined process and product composition data in terms of resulting product properties. The approach builds on the results of two successful prior technical efforts. One is the CAD/Chem methodology by AI WARE, Inc. for exploring relationships between product formulation and product properties. CAD/Chem is based on neural-net computing and evolutionary programming. Another contributing methodology is the QPA work (US Patent #5032525) relating process sensor data, process control actions and product properties. The result of this work will be a methodology for building material models for interpolation and extrapolation from existing experimental data.

## Approach

This effort explored and demonstrated how thin film deposition processes can be made more productive and more efficient through the use of automation aids for closed-loop process control. A combined use of computational intelligence procedures and materials data for the real-time interpretation of monitored multi-wavelength ellipsometry data were used to control the growth of thin films by molecular beam epitaxy (MBE). A genetic algorithm like optimization method was used to solve an inverse optical problem and estimate values of the complex refractive index and growth rate. This information was then used to provide optimal estimates of the composition of material being deposited. Control of the film growth was accomplished via crucible temperature adjustments in either feedforward or feedback modes depending on the circumstances.

## Benefits

Self-directed control technology can be uniquely exploited to achieve a new plateau in intelligent processing of materials - namely knowledge discovery as applied in the control of MBE and chemical vapor deposition (CVD) thin film processes. The models are accurate and useful because they realistically incorporate process information instead of just nominal compositions.

## Status

*Complete*

*Start date: June 1995*

*End date: March 1998*

## Resources

*Project Engineer:*

*David Conrad*

*AFRL/MLMR*

*(937) 255-8786*

*SBIR Funded*

*Contractor:*

*AI Ware Incorporated*

# Simulation-Based Design of Thin-film Materials Using Knowledge-Based Development

Contract Number: F33615-97-C-5845

ALOG Number: 1614

Technical Report Number: AFRL-ML-WP-TR-1998-4101

## Statement of Need

The widespread application of gradient materials in areas ranging from biomimetic and mechatronic materials for nondestructive sensing and micro-actuation, to nonlinear optical properties for threat and detection, and to multilayer films for unique combinations of properties is limited by the lack of a design environment. Future material systems will require a design environment for modeling and simulating gradient thin-film interfaces including thin-film to bulk materials interfaces across monolithic and composite materials. Of particular interest is the ability to enable the integrated design of bulk components comprised of monolithic alloys and/or polymer, metal, and ceramic matrix composites whose properties are enhanced by interfacial effects and/or multilayer thin-film coatings. Although computational materials science approaches offer the potential for such a design environment, innovative approaches are sought to mitigate computational complexity and cost issues.

## Approach

The approach addressed: 1) modeling the process by formulating the behavior of the atoms or molecules as rules; 2) simulating and visualizing the results including defects in the lattices and structures, doping, shape of film interface, thickness, and distribution of species; 3) developing a flexible design environment for rule-based modeling of atom-atom interactions; and 4) evaluating the optical and mechanical performance of the resulting thin-film on various shapes and materials. This project explored thin-film materials design at the atomic scale up to the microscale, focusing on the behavior of atoms, simulating and visualizing defects, and evaluating the optical and mechanical performance of the resultant films. Material microstructures were represented in terms of geometric nets created according to specific rules and governed by enumerated rules for interaction. Materials design issues are specifically related to composition, orientation, grain features, and various interface features. The simulations of interest included both physical models of behavior and the sensor signals required for process control.

## Benefits

This exploratory development program attempted to develop a design environment for modeling and simulating the thin-film deposition process. Dual use of this exploratory research is foreseen for integrated shape, material, and process design of high performance aerospace metals, ceramics and polymers. Aircraft and automobile propulsion system vendors providing multilayer films for component thermal and wear protection.

## Status

*Complete*

*Start date: May 1997*

*End date: February 1998*

## Resources

*Project Engineer:*

*David Conrad*

*AFRL/MLMR*

*(937) 255-8786*

*SBIR Funded*

*Contractor:*

*TechnoSoft Incorporated*

# 3-D Engineering Workstation for Connected Simulations

Contract Number: F33615-97-C-5844

ALOG Number: 1613

Technical Report Number: AFRL-ML-WP-TR-1998-4033

## Statement of Need

Materials insertion applications and spare components for aging aircraft systems offer tremendous opportunity to introduce innovative methods, processes and material systems to reduce weight and costs while improving wear, temperature and strength performance. The need is for material process design methods which consider alternative processing which lead to significant reduction in design and fabrication times. Of particular interest is the design and fabrication of precision tooling to enable materials substitution or replacement components that are lighter, stronger and less expensive than might be otherwise attained through conventional forging, casting and machining operations. Demonstration of reduced part turnaround and delivery with cost savings of 50 percent are a targeted goal. Methods, processes and materials should be functionally integrated via a feature-based design environment allowing selection and optimization of manufacturing methods, processes, and materials for structural aircraft and engine components.

## Approach

The purpose of this Phase I research project was to determine the feasibility for developing a 3D Engineering Workstation for designing custom precision forgings. An industrial advisory board was formed to guide the research, and it consisted of members from USCAR corporations, national laboratories and the parts supplier industry. Rules were developed for designing a graphical user interface (GUI) for non-analyst designers, and emphasis was placed on linking discrete simulations of different processes, e.g., forging, quenching and heat treatments, which are needed for producing a finished part. Gleeble testing was done, and the results show that thermal gradients can have a significant effect on the mechanical properties of aluminum alloy 7050. The inverse FEM was evaluated for determining surface heat transfer coefficients, and the feasibility for using thermal probes with important geometrical features of the part was shown to be a viable way for handling complex 3D geometries. The results of this work can be used to develop a design system for making custom netshape forgings more affordable for the DOD. The precision forging of netshape aerospace and automotive parts is of prime interest, because netshape forgings save energy, materials and reduce overall part cost. The approach of this Phase I SBIR was to: 1) form an advisory committee of forging and manufacturing experts for guidance and verification; 2) implement and demonstrate a prototype user-interface for connected simulation; 3) develop initial modeling components; 4) develop a methodology for material/manufacturing knowledge-base development.

## Benefits

Dual use of this exploratory research is foreseen for integrated shape, material, and process design of high performance metals, ceramics and polymers. Aircraft and automobile propulsion system vendors will provide tooling for forming new higher temperature alloys. This exploratory development program attempted to design and produce high quality machining-friendly forgings in reduced development time via the development of a 3-D connected simulation system, capable of both isolated and connected simulations. The connected simulation considered the connected sequence of forging, heat treatment, and machining.

## Status

*Complete*

*Start date: May 1997*

*End date: February 1998*

## Resources

*Project Engineer:*

*David Conrad*

*AFRL/MLMR*

*(937) 255-8786*

*SBIR Funded*

*Contractor:*

*Universal Energy Systems*

*Incorporated*

## Semi-Insulating Gallium Arsenide Wafers

(Page 182) Contract Numbers: F33733-94-C-1017/1019/1020 ALOG Numbers: 1301/1302/1303

### Technical Report Number: In Progress

The objective of this project was to assure a viable world-class domestic manufacturing capability to produce semi-insulating gallium arsenide (SI GaAs) substrates in support of Department of Defense (DoD) and commercial requirements. Primary applications for SI GaAs include microwave and millimeter wave integrated circuits. The material is an enabling technology for a variety of defense weapons systems. Title III incentives were used to encourage investment by domestic companies to improve the quality of their product and the efficiency of their production processes.

#### Status

*Complete*

*Start date: March 1994*

*End date: June 1998*

#### Resources

*Project Engineer:*

*John Blevins*

*AFRL/MLMP*

*(937) 255-3701, ext. 226*

*Title III Funded*

*Contractors:*

*American XTAL*

*Technology*

*Airtron Division of*

*Litton Corporation*

*M/A-COM, Inc.*

## Active Projects

### High Purity Float Zone Silicon

(Page 181) Contract Number: F33733-93-C-1014 ALOG Number: 1304

**Update** - The objective of this project is to re-establish a high-quality, low-cost domestic capability to produce high purity float zone (HPFZ) silicon. The technical objective of this project is to establish a domestic capability to produce up to and including 100 mm (~4 inch) diameter HPFZ silicon ingots. All material produced meeting the Title III Material Specification must be greater than 2,000 ohm-cm (n-type). In order to satisfy the exacting requirements for vidicons and infrared detectors, the contractor must demonstrate the capability to produce material greater than 25,000 ohm-cm (p-type). Product and process improvements will also be pursued to achieve greater quality and yields needed to be competitive in the global market.

#### Status

*Active*

*Start date: November 1993*

*End date: June 1999*

#### Resources

*Project Engineer:*

*John Blevins*

*AFRL/MLMP*

*(937) 255-3701, ext. 226*

*Title III Funded*

*Contractor:*

*UniSil Corporation*

### Semi-Insulating (SI) Indium Phosphide (InP) Wafers

(Page 183) Contract Numbers: F33733-97-C-1022/1023 ALOG Numbers: 1502/1549

**Update** - The objective of this project is to establish viable, long-term, world-class manufacturing capabilities for Indium Phosphide (InP). InP is a compound semiconductor material that is critical to a variety of optoelectronic and very high-frequency, millimeter wave, and high-power microwave electronics. DoD is investing heavily in the development of InP-based devices; however, the manufacturing infrastructure for InP wafers production is not capable of meeting DoD requirements with respect to quality, price, size and availability. Increased domestic production capacity for InP is required to support current and future needs for both military and commercial applications. Systems requiring InP include the following: BAT, BCIS, MILSTAR, GPS, MILSATCOM, GBR, F-22 and F-15. Important uses of InP are in the fabrication of heterojunction bipolar transistors (HBTs) and high-electron mobility transistors (HEMTs) for analog and digital devices. Title III incentives will be used to enable transition to full-scale manufacturing, improve affordability and quality, target military systems insertions, and leverage government investments.

#### Status

*Active*

*Start date: May 1997*

*End date: January 2000*

#### Resources

*Project Engineer:*

*John Blevins*

*AFRL/MLMP*

*(937) 255-3701, ext. 226*

*Title III Funded*

*Contractors:*

*American XTAL Technology*

*M/A-COM, Inc.*

# Small Flat Panel Displays

**Contract Number:** F33615-93-C-3608

**ALOG Number:**

## Statement of Need

The current Air Force standard NV/HUD System was originally developed jointly by Systems Research Labs (SRL) and the Air Force. This system when used in conjunction with ANVIS (F4949) Night Vision Goggles (NVGs) provides aviators with symbology that conveys flight information superimposed on the outside visual scan image of the NVGs. The primary role of the NV/HUD system was to increase crewmember safety during demanding NVG missions.

## Approach

The System utilized technology that was state-of-the art in the 1980's. This included a 400x400 pixel image with a high output one-inch CRT. The SRL NV/HUD has an installed customer base that includes PaveLow, PaveHawk, SOLL and Combat Talon Programs. Recent advancements in display technology has supported a breakthrough in NV/HUD design, packaging and performance.

## Benefits

Use of flat panel display technology greatly improves system performance while eliminating previous NV/HUD shortcomings. The objective of the Title III effort was to integrate a flat panel display into the NVGs, flight quality them on four USAF Special Operations Aircraft and demonstrate the manufacturability of the new NV/HUD system. The strong Tri-Service interest in this NV/HUD has resulted in additional flight qualifications with the Army and Navy. Following successful flight qualification, it is anticipated that 100s of NV/HUD systems will be procured for insertion into military and commercial platforms.

## Status

*Active*  
*Start date: March 1997*  
*End date: February 1999*

## Resources

*Project Engineer:*  
*John Blevins*  
*AFRL/MLMP*  
*(937) 255-3701, ext. 226*

*Title III Funded*

*Contractor:*  
*Tracor*

# Active Matrix Liquid Crystal Cockpit Displays

**Contract Number:** Numerous

**ALOG Number:** Numerous

## Statement of Need

The Desert Storm experience demonstrated that information is the primary currency used to secure both tactical and strategic military advantage. Visual displays are the primary interface between those making time-critical military decisions and their information resources. Current display systems are plagued by their size limitations, power consumption, weight, ruggedness and reliability considerations. Flat Panel Displays (FPDs) offer military users significant advantages over conventional displays such as Cathode Ray Tubes (CRTs) including: ability to fuse data from multiple sensors and present in ways that permit fast and effective real-time responses, rugged, light-weight, low power consumption, high resolution, wide viewing angle, sunlight readable, integration of information processing into the display, etc.

## Approach

In April 1994, the Department of Defense (DoD) announced the National Flat Panel Display Initiative. One of several thrusts of this initiative was performed through the Defense Production Act's Title III Program. The Title III effort, which focused on Active Matrix Liquid Crystal Displays (AMLCDs), worked to accelerate the insertion of AMLCD technology into DoD systems.

## Benefits

The positive impacts of the Title III Program were felt across the four services. Funded programs included the AH-64D, UH-60Q, CH-46, C-141, P-3C, F-18C/D, AV-8B, F-18E/F and Drivers Viewer Enhancer. The Title III Program successfully stimulated military demand for over 4,000 AMLCDs.

## Status

*Active*

*Start date: August 1994*

*End date: January 1999*

## Resources

*Project Engineer:*

*John Blevins*

*AFRL/MLMP*

*(937) 255-3701 ext. 226*

*Title III Funded*

*Contractor:*

*Numerous*

Title III

Title III

# Power Semiconductor Switching Devices (PSSDs)

Contract Number: F33615-98-C-5853

ALOG Number:

## Statement of Need

The objective of this project is to establish an assured, affordable, and commercially viable production capability for high quality power semiconductor switching devices (PSSDs). These solid-state devices replace electromechanical switches for both medium and high-power military and commercial electrical applications. PSSDs have increased switching efficiency and power handling capability while having reduced space requirements, acquisition costs, and life-cycle costs compared to electromagnetic switches. They are pervasive in a wide variety of power generation, control, conversion, and conditioning applications in both defense and commercial sectors.

## Approach

Title III financial incentives will be used to transition a variety of devices to full-scale manufacturing, improve yield, quality and affordability, as well as target military and commercial insertion opportunities. To ensure that the requirements of each service are met, technical assistance to the Title III Program Office will be provided by scientist and engineers from AFRL Materials and Manufacturing Directorate, AFRL Propulsion Directorate, the Office of Naval Research, and the Army Research Laboratory.

## Benefits

PSSDs are essential to the development and deployment of advanced Air Force, Navy, and Army "more-electric" weapon systems, removing a major barrier to replacing hydraulic systems with electrical systems as well as providing power switching solutions for directed energy weapons and electromagnetic launchers.

## Status

*Active*

*Start date: August 1998*

*End date: December 2003*

## Resources

*Project Engineer:*

*Philip Tydings*

*AFRL/MLMP*

*(937) 255-9665 ext. 223*

*Title III Funded*

*Contractor:*

*Silicon Power*

*Corporation (SPCO)*

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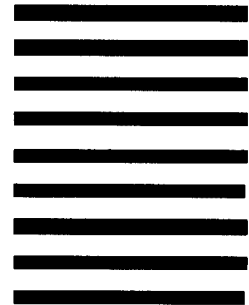


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